PHOENIX CONTACT
INSPIRING INNOVATIONS

RAD-ISM-900 Data Radio Series User Manual

Receive
Transmit
13 14 15 16
1 2 3 4
WARNING: EXPLOSION HAZARD
Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

1845A022

RAD-ISM-900 Data Radio Series User Manual

RAD-ISM-900-RS232-BD
RAD-ISM-900-DATA-BD
RAD-ISM-900-DATA-BD-BUS

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This Manual Contains Information on the

The RAD-ISM-900
Data Radio Series User Manual

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I. Warranty

Phoenix Contact Inc. warrants its wireless products against defects in materials and workmanship under normal use and service for a period of 12 months from the date of purchase.

During the warranty period, products determined by Phoenix Contact to be defective, shall at the option of Phoenix Contact, either be repaired at a location authorized by Phoenix Contact (and returned free of charges for parts, labor, or shipping), or replaced with an equivalent product. Defective parts replaced by Phoenix Contact shall become the property of Phoenix Contact. This Limited Warranty does not cover on-site repair of products. Defective products must be returned to Phoenix Contact to be repaired or replaced. Phoenix Contact is not responsible for the operation, damage, availability, or loss of use, of the customer supplied equipment being used with a wireless product.

This warranty is void under the following circumstances:

1. Abnormal use of the product or use in violation of the instructions provide in this manual
2. Improper and/or unauthorized installation or repair of system components

A. Important Notice (RF Exposure)

This product is intended for fixed installation applications. In order to comply with FCC/ISC adopted RF exposure requirements, installation of this transmitter system's antennas must be performed in a manner that will provide at least a 6 foot (2m) clearance from the front radiating aperture to any user or member of the public.

B. FCC Part 15 Compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by Phoenix Contact will void the user's authority to operate the equipment.
FCC Part 15.247
ISC RSS 2101

C. FHSS (Frequency Hopping Spread Spectrum)

The DATA series of radios utilize a frequency hopping spread spectrum (FHSS) method of transmitting data. A FHSS radio changes frequencies in a pseudo random fashion thereby avoiding interference and increasing the reliability. Originally designed for battlefield communications, FHSS provides secure, reliable communications in industrial environments.

II. About this Manual

In order to guarantee the safe use of your device, we recommend that you read this manual carefully. The following notes give you information on how to use this manual.

A. Requirements of the User Group

The products described in this manual should be installed/operated/maintained only by qualified application programmers and software engineers, electricians or persons instructed by them. Phoenix Contact assumes no liability for damage to any products resulting from disregard of information contained in this manual.

B. Purpose of this Manual

This manual contains the information necessary to understand and to configure a Phoenix Contact wireless serial data modem.

III. Using This Manual

This manual contains the information necessary to understand, install, operate, and order parts for Phoenix Contact wireless serial data modem and associated components. The table of contents at the front of this manual provides a paragraph-by-paragraph breakdown of the subject matter covered in each section.

Specifications within the text of this manual are given in the International System of Units (SI), with English equivalents in parentheses. Fully capitalized words within the text indicate markings found on the equipment. Warnings, Cautions and Notes are used to emphasize critical instructions:

WARNING

An operating procedure, practice, etc., which, if not carefully followed, could result in personal injury.

CAUTION

An operating procedure, practice, etc., which, if not strictly observed, could result in damage to the equipment.

NOTE

Highlights important information about an operating procedure or the equipment.

A. Finding Information

For ease of finding specific information in this manual, we have provide the following help:

- A main table of contents covering all subject matter is provided at the front of this manual.
- A table of contents covering information within a section or an appendix is provided at the front of each individual section or appendix.

B. Additional or Related Documentation

For specific information on the individual expansion I/O modules, see the corresponding module-specific data sheets.

C. Current Documentation on the Internet

Make sure you are always working with the latest documentation published. The latest changes or additional information can be found on the Internet at:

http://www.phoenixcon.com (Info Service)

D. Statement of Legal Authority

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E. Validity of Documentation

This manual mainly contains a description of RAD-ISM-900 Serial Data Modems that were available when this manual was published.

Phoenix Contact reserves the right to make any technical extensions and changes to the system that would serve the purpose of technical progress. Up to the time that a new manual revision is published, any updates or changes will be documented on the Internet at:

http://www.phoenixcon.com (Info Service)

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1.1 General

The RAD-ISM-900 Data Series family consist of three types of data radios. This section provides general information about these radios.

- RAD-ISM-900-RS232-BD
- RAD-ISM-900-DATA-BD
- RAD-ISM-900-DATA-BD-BUS

1.2 Data Radio Series Descriptions

1.2.1 RAD-ISM-900-RS232-BD

A 1-watt transceiver for RS232 protocols, this radio features assured modes for Modbus RTU and Allen-Bradley DF1 protocols. It also has a secondary remote diagnostics port.

1.2.2 RAD-ISM-900-DATA-BD

A 1-watt transceiver for RS232 and RS-422/485 protocols, this radio features assured modes for Modbus RTU and Allen-Bradley DF1 protocols. It also has a secondary remote diagnostics port.

1.2.3 RAD-ISM-900-DATA-BD-BUS

A 1-watt transceiver for RS232 and RS-422/485 protocols, this radio features assured modes for Modbus RTU and Allen-Bradley DF1 protocols. It can operate in PLC emulation mode, where expandable I/O modules may be bussed on to the radio and addressed via Modbus RTU or DF1. Remote diagnostics may also be performed using this radio with some restrictions (see section 2.3).

1.2.3.1 I/O Expansion Modules and their Functions

I/O expansion modules may be bussed onto a RAD-ISM-900-DATA-BD-BUS to read or write analog (0-22mA) or digital (on/off) signals from sensors or other process equipment using Modbus RTU or Allen-Bradley DF1. A RAD-IN-4A-I module will accept four (4) analog input signals. A RAD-OUT-4A-I module will output four (4) analog signals, with available 24VDC connections to power a device. A RAD-IN-8D module will accept eight (8) digital input signals (5-36VAC/DC), while a RAD-OUT-8D-REL will give eight (8) digital relay contacts (2A at 250VAC/30VDC). The RAD-IN+OUT-2D-1A-I module features one (1) each analog input, analog output, and two (2) each digital input and digital output.

1.3 Interoperability

All radios in the data series are interoperable. This means that as long as the protocol is the same throughout the network, any of the radios may be used. Moreover, RS-232 and RS-422/485 may be used in the same network with no converter necessary. For example, a RAD-ISM-900-RS232-BD may be used as a master to a RAD-ISM-900-DATA-BD operating in RS-485/422 mode with an RS-485/422 slave device.

1.4 Remote Diagnostics

The remote diagnostics feature allows the user to connect to the master radio using RADLink software for remote programming and system health information. Each slave radio will be polled for critical operating information. All radios have the same remote diagnostics capability with the exception of the DATA-BD-BUS when it is functioning as a master. Due to a lack of a secondary serial port (the secondary port is the 5-pin BUS connector), a DATA-BD-BUS radio when acting as a master and having data passed through its primary port, cannot access remote radios for diagnostics purposes using the RADLink software or AT commands. You can access these functions through the primary serial port, but that means the host PC/PLC must be disconnected. Therefore if you require this feature, you should use either the RS232-BD or DATA-BD as the master.

1.5 Features and Benefits of the DATA Series

The RAD-ISM-900 Data series uses state of the art technology and components to deliver reliable, unsurpassed performance. Some of these features include:

- **Frequency Hopping Technology –** to ensure radio performance in noisy industrial plant environments
- **High Quality Filters –** on the receivers to prevent unwanted RF noise from interfering with the desired signal.
- **Surface Mount Components –** to decrease the size of the RAD-ISM-900-RS232-BD to allow mounting in small enclosures.
- **Iris Radio Protocol –** a proprietary RF protocol developed to increase data security and enable features such as auto-routing.
- **Remote Diagnostics Port –** an auxiliary port that can be used to query and program remote RAD-ISM-900-RS232-BD's.
- **RF Link Dry Contact –** a contact that changes state if the radio link is lost – allows for wiring equipment in a failsafe fashion or simplifying PLC code by monitoring its condition for communications status.
- **Received Signal Strength Indicator –** a voltage test point that indicates how strong the received signal is – simplifying antenna aiming.

1.5.1 Spread Spectrum Systems

Spread Spectrum (SS) this is one of the newest technologies to be applied to radio-based SCADA systems. Originally developed to provide jam-resistant military communications, Spread Spectrum uses a modulation technique that distributes a transmitter's signal over a very wide bandwidth, making it virtually undetectable to a conventional radio receiver, or what the military calls Low Probability of Intercept (LPI).

Two SS techniques commonly used today are -Frequency Hopping and Direct Sequence. Frequency hopping systems employ a narrow band, channel-switching scheme whereby the transmitter moves rapidly among a pre-determined set of frequencies. The time spent on any one frequency is only a fraction of a second. The receiving station(s) are programmed to "follow" the transmitter in step with the hopping pattern.

Direct sequence radios spread their RF energy across a wide "chunk" of spectrum rather than hopping among discrete channels. The amount of energy on any frequency is extremely low, but when the signal is "de-spread" at the receiving end through a compression, a usable signal results. Direct sequence systems are commonly used in short-range LAN applications.

1.5.1 License-free advantage

A major advantage of Spread Spectrum is that many users can occupy a given band at the same time without causing serious interference to one another. This has promised many countries to permit license-free operation of SS systems with certain restrictions.

In the United States, for example, no license is required for 902-928 MHz SS operation with a maximum transmitter power of 1 watt (30 dBm) and an antenna system gain that limits effective radiated power (ERP) to 36 dBm or less. This means that for a one 1 watt transmitter, an antenna system with 6 dB of gain may be used. When antenna systems of greater gain are used, transmitter power must be decreased accordingly by cumulative signal losses in connectors, cables and surge arrestors.

SS is an ideal solution in many SCADA applications because it eliminates the time and expense involved with licensing while providing a level of performance that can approach licensed systems. However, because of the output power and antenna gain limits imposed on SS systems, station efficiency is even more critical than with licensed networks. The path planning, antenna, and co-axial cable issues discussed earlier apply in whole for FHSS systems.

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2.1 Programming the Radio

2.1.1 Common Parameters to all Radios

1. Apply 24VDC power to the radio.
2. Connect a straight through cable from the serial port of your computer to the serial port of the radio.
3. Download and run the RADLink software.
4. Select “Project”, “Configure Com Port…” from the pull down menus.
5. Select the Com port number that correlates to the Com port the radio is connected to, and select data format of 9600 baud, 8 data bits, 1 stop bit and no parity.
6. Randomly enter a Group ID, Security ID and RF band. Write these values down as they need to be set the same on all radios.
7. Select “Master” for Radio Mode on only one of the radios, and enter a Radio ID of 0.
8. All other radios program as slaves. Give each one a different Radio ID starting at 1 and counting up.
9. Disable “Auto-Routing” and ensure the data format is set to the values described in step 4.
10. Enable or disable handshaking in order to match the serial device it will be connected to.
11. Enable or Disable buffering as required by the protocol. (Modbus requires Packet Mode (buffering enabled) whereas DF1 protocol requires Character Mode).
12. Select “Set Radio” to download these settings to the radio.

2.1.2 Additional Parameters for the RAD-ISM-900-DATA-BD

1. Remove power from the radio and press in the release tabs on either side of the radio just below the terminal blocks. Remove the plastic housing from the circuit board exposing the DIP switches.
2. Set the DIP switches accordingly to configure for use with RS-232/485/422.
3. Re-install the housing.

2.1.3 Additional Parameters for the RAD-ISM-900-DATA-BD-US

1. In the RADLink software, under RAD-ISM-900, select “DATA-BD-BUS” and select “Setup”
2. Select the Emulation mode desired, primary communications port, and assign a PLC address. Each radio must have a different PLC address.
3. Select “Apply” and then select “Set Radio” to download these settings to the radio.

2.2 Installing and Commissioning the Radios

2.2.1 Common Parameters to all Radios:

1. Connect each device to the radio’s RS-232 port or 485/422 port as selected in the software or DIP switches (if applicable).
2. Connect the antenna to the gold antenna connector on the top of the radio and mount the antenna.
3. Apply power to the radio and commence communications.

2.2.2 Unique Parameters to the RAD-ISM-900-DATA-BD-BUS

1. Plug in Analog/Digital/Input/Output module(s) to each slave radio.
2. Wire Analog/Discrete signals to the I/O module(s).
3. Refer to the Address Map in Section 6.5.1 to determine what input/output channels are mapped to which registers.

SECTION 3

Making Connections and Powering Up

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3.1 Power Connections

The radios can be powered from a DC voltage ranging from 9 to 30VDC. The power supply should be regulated and not fluctuate by more than 10% of its rated output. See Figure 3-1. It is recommended that a voltage surge arrestor be installed to prevent power surges from damaging the equipment. The wiring between the surge arrestor and the radio should be as short as possible, following the manufacturer's guidelines.

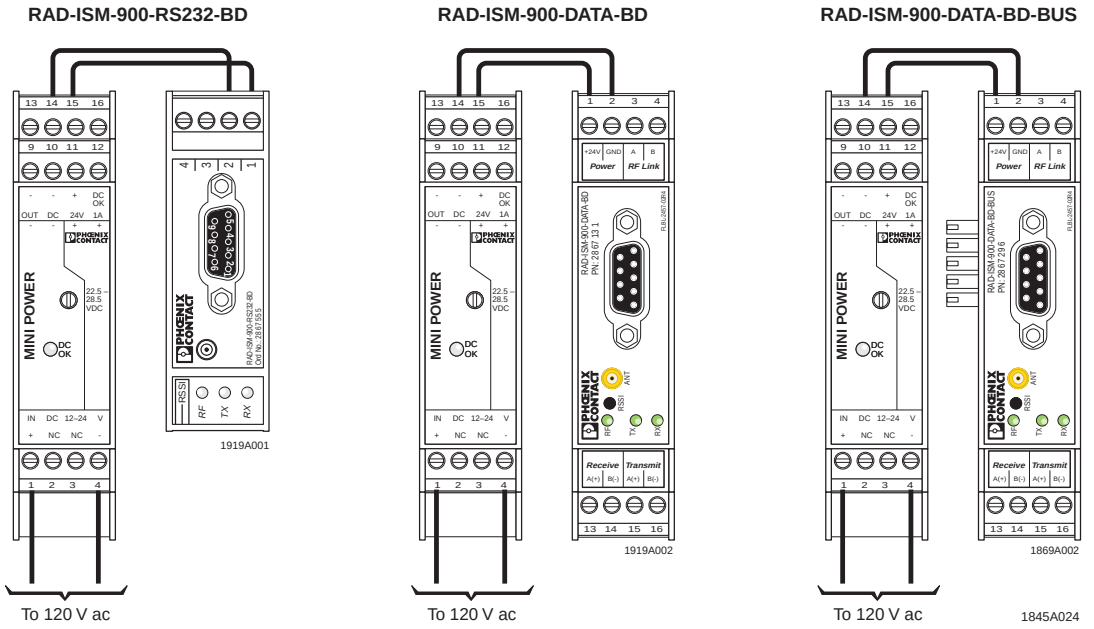

Figure 3-1. Data Series Radio to Power Supply Connections

3.2 RS232, RS485 and RS422 Serial Port Connections

3.2.1 RS-232

In order to program the radio using the RADLink software, you will need to connect the radio to your computer's serial port. The interconnecting cable needs to have DB9 connectors on each end and wired in a “straight through” fashion.

When you have the correct RS232 cable connecting the radio to the computer or PLC/industrial instrument, the TX LED on the radio will go solid green when power is applied to both devices. (This TX LED will also flash when data is passed).

Note on Serial Cables: There are 2 types of serial port cables that both have DB9 (9- pin sub D) connectors. See Figure 3-2. One is called a straight through 9-pin serial port cable and the other is called a null modem cable. On a straight through cable, it is wired as just that – straight through, in other words, pin 1 is connected to pin 1, pin 2 to 2, etc. A null modem cable crosses over pins 2 and 3 (transmit and receive data) and also crosses over pins 7 and 8 (clear-to-send (CTS) and ready-to-send (RTS)). A null modem cable is designed to allow two devices to be connected together when they both function as data terminal equipment (DTE) or when they both function as data communications equipment (DCE). By swapping the pins, it connects inputs to outputs and vice versa for proper operation.

Equipment with serial ports can be designed as either DTE or DCE. This determines the functions of pins 2 & 3, and 7 & 8. For example, if pin 7 is an output on one end, then it will have to be an input on the other end. Computers are typically designed as DTE whereas modems and radio modems are designed as DCE. Programmable Logic Controllers (PLC’s) flow computers and other industrial instruments could be either DCE or DTE.

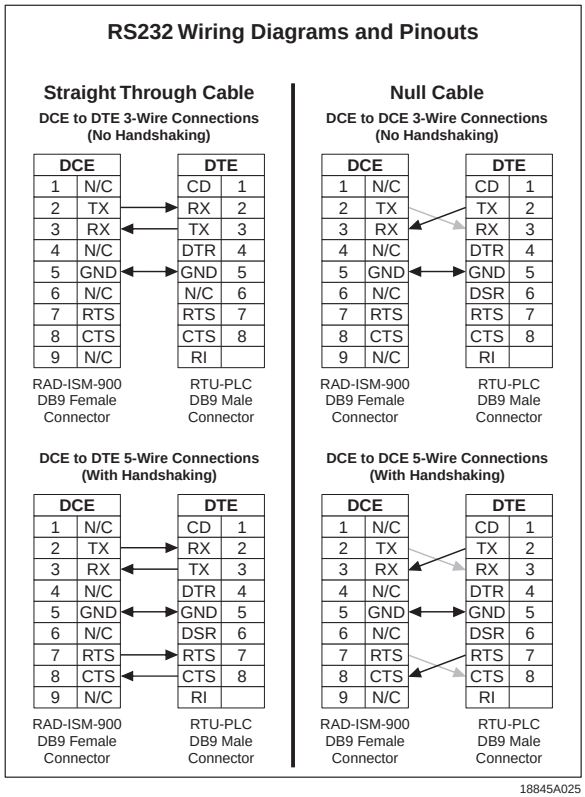
RS232 Wiring Diagrams and Pinouts
Straight Through Cable
DCE to DTE 3-Wire Connections (No Handshaking)
DCE 1 N/C 2 TX 3 RX 4 N/C 5 GND 6 N/C 7 RTS 8 CTS 9 N/C
DTE CD 1 RX 2 TX 3 DTR 4 GND 5 N/C 6 RTS 7 CTS 8 RI
RAD-ISM-900 DB9 Female Connector
RTU-PLC DB9 Male Connector
DCE to DTE 5-Wire Connections (With Handshaking)
DCE 1 N/C 2 TX 3 RX 4 N/C 5 GND 6 N/C 7 RTS 8 CTS 9 N/C
DTE CD 1 RX 2 TX 3 DTR 4 GND 5 DSR 6 RTS 7 CTS 8 RI
RAD-ISM-900 DB9 Female Connector
RTU-PLC DB9 Male Connector
Null Cable
DCE to DCE 3-Wire Connections (No Handshaking)
DCE 1 N/C 2 TX 3 RX 4 N/C 5 GND 6 N/C 7 RTS 8 CTS 9 N/C
DTE CD 1 TX 2 RX 3 DTR 4 GND 5 DSR 6 RTS 7 CTS 8 RI
RAD-ISM-900 DB9 Female Connector
RTU-PLC DB9 Male Connector
DCE to DCE 5-Wire Connections (With Handshaking)
DCE 1 N/C 2 TX 3 RX 4 N/C 5 GND 6 N/C 7 RTS 8 CTS 9 N/C
DTE CD 1 TX 2 RX 3 DTR 4 GND 5 DSR 6 RTS 7 CTS 8 RI
RAD-ISM-900 DB9 Female Connector
RTU-PLC DB9 Male Connector
18845A025

Figure 3-2. Wiring Diagram - RS232 Port Interface

To connect a DCE device to a DTE device, a straight through cable is used. To connect two DCE devices together or to connect two DTE devices together, a null modem cable is required.

3.2.2 RS485 and RS422 – Unique to the RAD-ISM-900-DATA-BD and the RAD-ISM-900-DATA-BD-BUS

One set of terminals (13 – 16) can be used to connect the radio to external devices using RS485 or RS422 – differential standards typically used for the transmission of data over much greater distances than is possible with RS232. Both 2-wire and 4-wire configurations are supported. See Figure 3-3. Although the 4-wire configuration supports full duplex communications, the radio is only half duplex over the air.

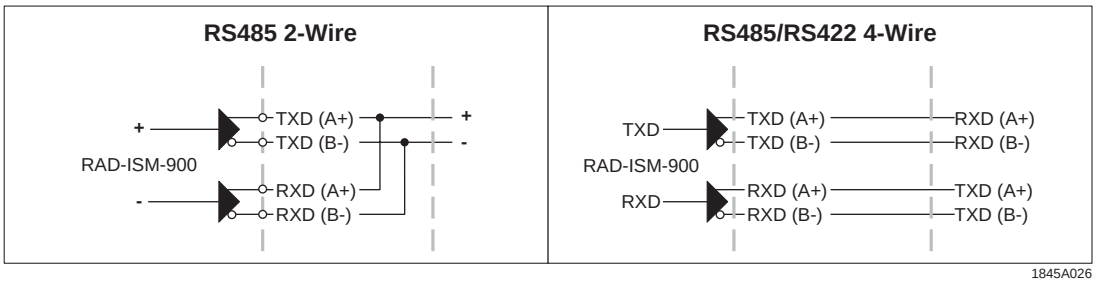

Figure 3-3. Wiring Diagram - RS485 and RS485 /RS4222

3.2.3 Serial Port Selection DIP switches – Unique to the RAD-ISM-900-DATA-BD

On the RAD-ISM-900-DATA-BD there are internal DIP switches that determine which serial port is to be used. They allow selection of RS232 port or the RS485/422 port, and they also determine if the RS485/422 port is to operate in 2-wire or 4-wire configuration.

To adjust the port, do the following:

1. Using a small slotted screwdriver, press in on the latch located just below the terminal blocks on either side of the housing. Then while holding the latch depressed, slide the plastic housing down to expose the DIP switches. See Figure 3-4.

Figure 3-4. Opening Housing to Access DIP Switches

2. Using a slotted screwdriver, adjust the DIP switches according to the labels next to them. See Figure 3-5.

Switch 1	RS232 Port	OFF
Switch 1	RS422/RS488	ON
Switch 2	2-wire half duplex	OFF
Switch 2	4-wire full duplex	ON
Switch 3	Not connected	
Switch 4	Not connected	

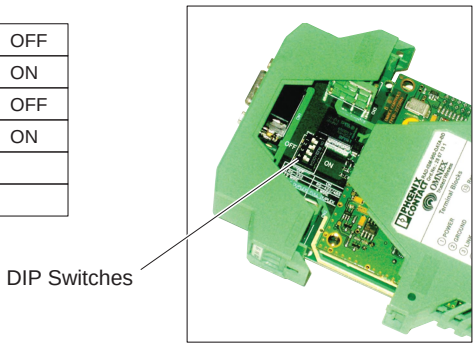

Figure 3-5. DIP Switch Setings

3. Re-install the plastic housing onto the circuit board.

Note

If you have selected the RS485/422 port for data communications with your PLC's/industrial instruments, but wish to reprogram the radio using the RADLink software, you will need to reset the radio for RS232 communications. Once programming is complete, you can then set the radio for RS485/422 communications and connect to your end devices.

One radio can be connected to end devices using RS232 and other radios can be connected to end devices using RS-485 or 422. All radios in a network do not have to be set the same.

3.3 Antenna Connections

An antenna should be connected to the gold antenna connector on the top of the radio, labeled "ANT". See Figure 3-6. The connector on the radio is an MCX female. If the transmission distance is less than 50 feet, the radios may link with no antennas connected. This is suitable for bench testing, however when the radios are installed in their final location, an antenna should be connected to provide a load for the RF power amplifier.

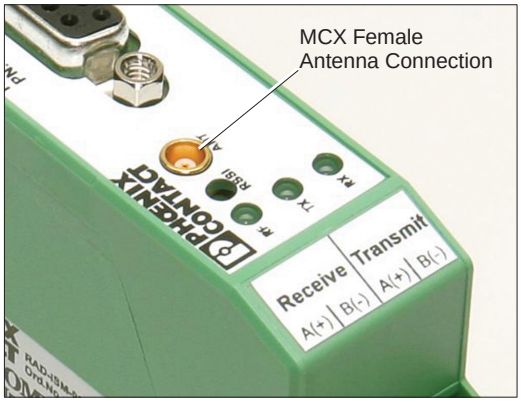

Figure 3-6. Antenna Connection (Typical on all radios)

CAUTION

The antennas of two radios should never touch each other to prevent overloading the RF power amplifier.

Caution should be used to prevent ground loops caused by the antenna ground (through the antenna mounting bracket), power supply ground and possibly the RS-232/ 485 connection ground. All of these should use a single ground point to prevent ground loops.

Notes

The shield of the antenna can be grounded or ungrounded. It does not affect the performance or RF propagation. It does have an impact on lightning protection.

Refer to Section 9 for more information about antenna systems.

3.4 Power and Communications Bus Connections on the RAD-ISM-900-DATA-BD-BUS

Unique to the RAD-ISM-900-DATA-BD-BUS is a 5-pin male and 5-pin female connector on either side of the radio. See Figure 3-7. This allows I/O modules to be connected to the radio. Data communications and power are transmitted through this connector to the I/O modules. Up to 8 I/O modules can be connected to each transceiver. Any combination of the different types of I/O modules can be connected to each radio.

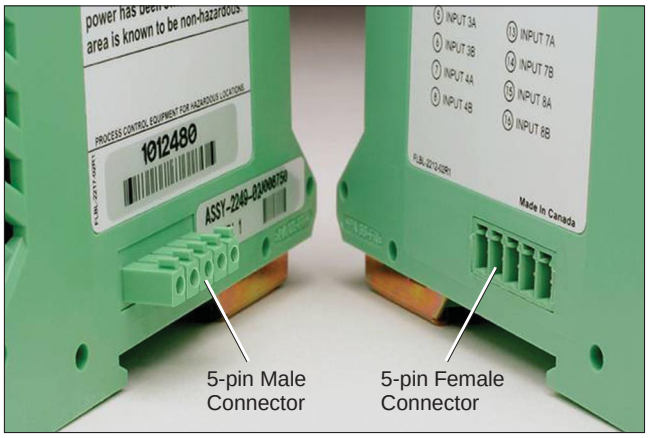

Figure 3-7. RAD-ISM-900-DATA-BD-BUS Bus Connectors

The modules can be connected to either side of the radio. In hot climates, it is recommended that all of the I/O modules be connected to only one side of the radio to maximize heat dissipation.

See Section 5.0 for more details on the I/O modules.

SECTION 4
Programming the Radio

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4.1 Navigating the RadLink Software

Configuration of the radio is done using the RadLink software or through a terminal program with AT commands. Refer to Section 10 for more information on "AT" commands and
"S" registers. (Optionally, the RAD-ISM-900-DATA-BD-BUS can be configured using internal DIP switches) RadLink software is freeware and can be downloaded by owners of Phoenix Contact radio products free of charge. To download RadLink, visit our web sit at: **http://www.phoenixcon.com/wireless**.

RadLink software requires Windows 98, XP or 2000, 2MB of hard drive space, minimum 600 by 800 screen resolution, and a RS232 serial port (or USB port with a USB to RS232 converter). Run the software by double clicking on the RAD-Link.EXE file.

4.2 The RadLink Software Main Screen

When you start the RadLink program, you will see the main menu screen, Figure 4-1. From the main menu, you have access to the *Project*, *Online Monitor* and *Help* menus. The main menu also contains *Defaults, Set Radio* and *Blocked MHz* buttons. A description of each menu and button is provided in the following paragraphs.

4.2.1 Project Menu

The Project pulldown menu provides access to the Com Port menu and to Projects menu. It also allows you to save each radio setting to your computer's hard drive. For information on saving and loading projects, refer to Paragraph 4.6.

4.2.2 Online Monitor Menu

The Online Monitor pulldown menu allows you to turn ON or OFF online monitoring of remote radios through the master. For more information on using this feature, refer to Online Monitor Function under Paragraph 4.6.2 of this section and to Remote Diagnostics Using RadLink Software in Section 10.

4.2.3 Help Menu

The Help pulldown menu provides access to the Terminal program and the About screen. The Terminal program is useful to determine what commands the RadLink software is sending to the radio and what responses the radio is sending back.

Running the Terminal program in the background with RadLink in the foreground can assist you in troubleshooting communication difficulties between the PC and the radio. The Terminal program is also used if you desire to program the radios using AT commands. For more information on programming using AT commands, refer to Section 10.

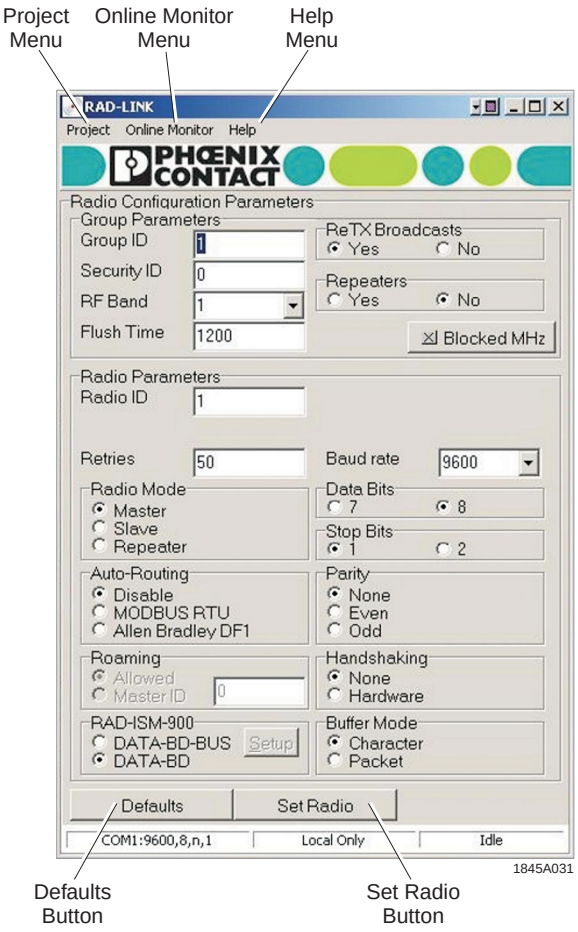


Figure 4-1. RadLink Program Main Menu

4.2.4 Defaults Button

The Default button sets all parameters on the menu screen back to their factory default values.

4.2.5 Set Radio Button

The Set Radio button downloads the parameters from the RadLink software to the radio.

4.3 Configuring your PC to Communicate with the Radio

Power must be applied to the radio to program it. Refer to Section 3 for power connections and serial port connections.

Note

If your RAD-ISM-900-RS-232-BD or RAD-ISM-900-DATA-BD has been powered on for more than 5 minutes, it cannot be programmed. Cycle power on the radio to reset the timer. This feature was implemented to allow the radios to be compatible with telephone modems for hybrid networks which have both telephone and radio modems.

Select "Project", "Configure Com Port..." from the pulldown menus. See Figure 4-2. Select the Com port the radio is connected to, and port settings (baud rate, data bits, stop bits and parity). The PC's com port settings must match the radio's setting. The factory default values are 9600, N, 8, 1. If you are unsure of the radio's settings, use the "Auto Configure" feature to have the PC try all possible combinations.

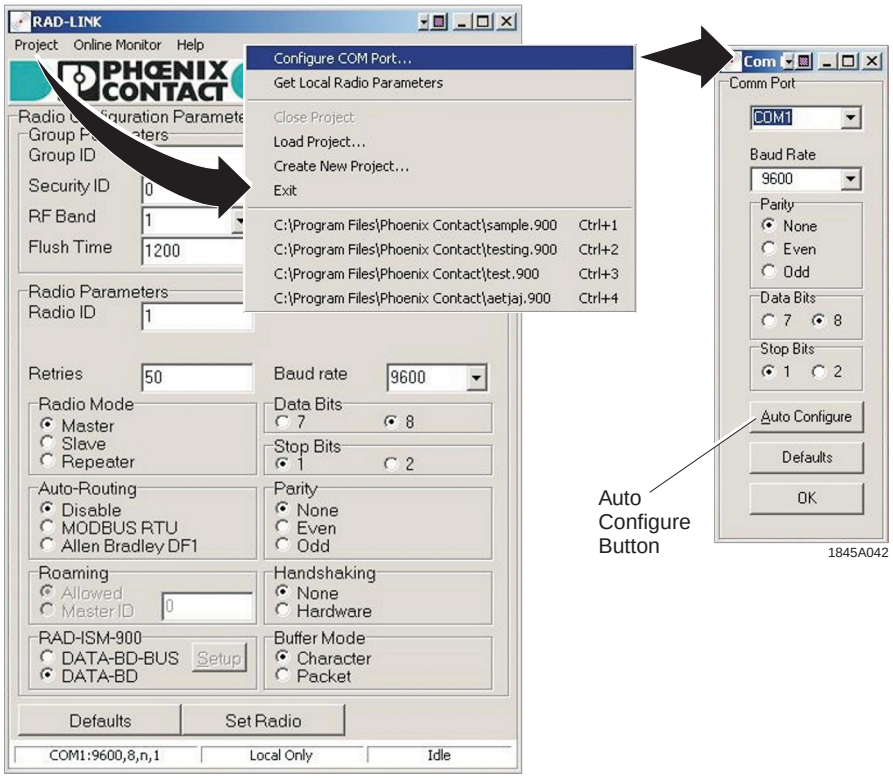


Figure 4-2. RadLink Program Configure Com Port Menu

4.4 Setting Group Parameters

All radios in a network (that are to communicate with each other) must have the same Group Parameters. See Figure 4-3.

Note

If your RAD-ISM-900-RS-232-BD or RAD-ISM-900-DATA-BD has been powered on for more than 5 minutes, it cannot be programmed. Cycle power on the radio to reset the timer. This feature was implemented to allow the radios to be compatible with telephone modems for hybrid networks which have both telephone and radio modems.

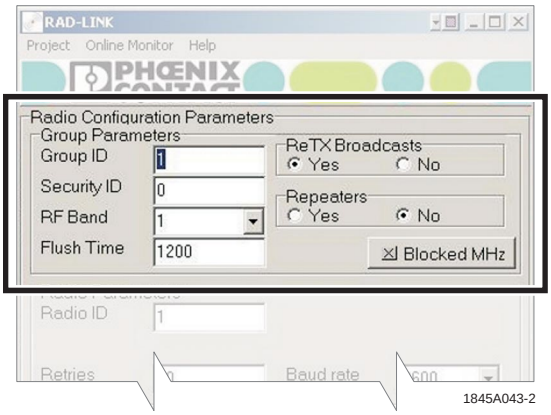


Figure 4-3. Group Parameters for Programming Radio

4.4.1 Group ID

The Group ID determines which hopping sequence the radios will use. Valid values are 1 to 63. Select a random Group ID to prevent interference from a neighboring user.

4.4.2 Security ID

The Security ID is a 16 bit number that helps ensure that a radio will not communicate with a neighboring network of radios even if the same Group ID and RF Band are selected. Select a random Security ID.

4.4.3 RF Band

The RF Band determines which of 4 RF Bands the network will use. The entire 902 to 928MHz ISM band is divided into 4 separate bands. Each band is interleaved to prevent multi-pathing problems. A band consists of 64 different frequencies. No two bands use the same frequency. If you have two neighboring networks, by assigning them different RF bands, you will ensure that there will be no interference from one to the other. If you have more than 4 networks within range of each other, use different Group ID's on networks that share the same band.

4.4.4 Flush Time

This parameter only has an impact if **Auto-Routing** is enabled. Refer to Auto-Routing under Paragraph 4.5.4 for a complete description of this parameter.

4.4.5 Re TX Broadcasts

When this feature is enabled, the master radio repeats all outbound messages twice, on different frequencies. When not enabled, the master radio sends all outbound messages only once. It is recommended that this feature be enabled in high interference environments or where there are weak radio links to increase the reliability. There is a slight penalty in response time, as the master radio will take twice as long to send an outbound message, when enabled.

4.4.6 Repeaters

If there are any repeaters in the network, all radios in the network must be aware of this.

4.4.7 Blocked MHz

By selecting this button, you can enter frequencies that will cause the radio to skip these frequencies in its hopping pattern. For example, if by using a spectrum analyzer it was determined that a variable frequency drive or other piece of equipment was causing interference on a certain frequency, that frequency can be skipped. This would increase the response time of equipment by preventing the radio from retransmitting data on a different frequency. Up to 12 frequencies can be blocked. Enter frequencies to the nearest 100KHz. (i.e. 905.6MHz)

4.5 Setting Individual Radio Parameters

The lower half of the main menu in the RadLink software sets the parameters for each individual radio. See Figure 4-4. Each radio can have different settings, and must have different settings in some cases.

Note

If your RAD-ISM-900-RS-232-BD or RAD-ISM-900-DATA-BD has been powered on for more than 5 minutes, it cannot be programmed. Cycle power on the radio to reset the timer. This feature was implemented to allow the radios to be compatible with telephone modems for hybrid networks which have both telephone and radio modems.

4.5.1 Radio ID

Each radio in a network must have a different ID. This is used by the receiving radio to determine the source of the message and identifies which radio the acknowledgment must be sent to.

4.5.2 Retries

This parameter only affects slave radios and repeater/slave radios unless Auto-Routing is enabled. See **Auto-Routing** for more information if programming a master radio and utilizing the **Auto-Routing** feature. On a slave radio, this parameter determines how many times the slave will attempt to send its message back to the master. The master acknowledges all messages. If a master radio has not acknowledged the message, the slave will retry communications the number of times specified. A higher setting is recommended for weak radio links and high interference environments whereas other slaves that are closer to the master and/or are in low interference areas could have lower settings.

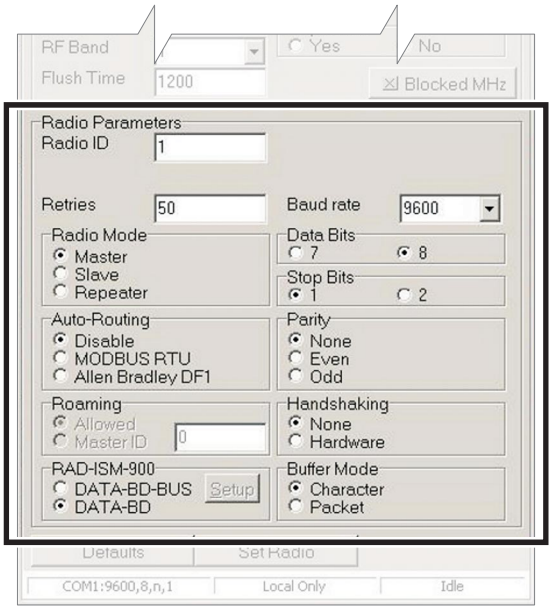


Figure 4-4. Setting Individual Radio Parameters

4.5.3 Radio Mode

This allows selection of master, slave or repeater. There can only be one master in any network and up to 254 slaves and repeaters. When a radio is programmed as a repeater, it also can function as a slave. A repeater uses store-and-forward technology such that only a single radio is required for repeater operation. This allows for a cost effective network design, in that a slave location can also function as a repeater for more distant slaves. There is no limit on the number of repeaters that can be used in a network. Refer to Section 8.0 for more information on the different network topologies that can be implemented.

Note

Repeater radios will typically require omnidirectional antennas, in the event that its master and slave(s) are outside of the beam width of a yagi antenna.

4.5.4 Auto-Routing

This feature will increase the reliability of radio communications when using either Modbus RTU or Allen Bradley's DF1 protocol. It will not work with other protocols. It works by monitoring the PLC address within each command and noting which slave radio transmitted that data. The master radio then creates a table that correlates which slave radio is connected to each PLC. During the first round of polling, the master radio monitors communications and builds the table. In subsequent polls, the master requests an acknowledgment from the target slave radio that it received the message. If the slave does not acknowledge the message, the master will re-send the message the number of times specified in Retries. After all retries have been attempted, the master will give up.

Related to *Auto-Routing* is Flush Time. Flush Time is the amount of time the master radio stores the Auto-Routing table before discarding and reconstructing. It is necessary to reconstruct the table periodically in the event that a repeater has lost power (or suffered some sort of failure) and the path is being rerouted through a different repeater.

Note

During initial bench testing and system commissioning, it is recommended that Auto-Routing be turned off. This is because if you are changing radio ID's and PLC addresses, it may cause the network not to function until the table correlating the two has been discarded (flushed).

4.5.5 Roaming

This feature allows a slave radio to either lock onto a specific master or repeater, or to allow it to communicate through any repeater. Most of the time, roaming is recommended, since it will allow a slave to reroute its data communications path rather than lose communications. However for slave radios that are very close to the master and are also close to a repeater, you may wish to disable roaming and enter the master radio's ID number. This would prevent the slave from locking onto the repeater, and slowing its response time.

If roaming is disabled, you must enter the Radio ID of the master or repeater. The slave will then only be able to communicate with the radio with this ID.

Note

When designing the system, if roaming is enabled, antenna selection may have to be modified so that the slave can communicate with other repeaters. Typically this means using omni directional antennas. Refer to Section 8 for more information on system design.

4.5.6 RAD-ISM-900

This is not a parameter that can be downloaded into the radio. When "Get Local Radio Parameters…" is selected, the software reads what model of radio it is communicating with and selects the buttons accordingly. There are additional parameters that can be set on the RAD-ISM-900-DATA-BD-BUS that are accessed through the button adjacent to the DATA-BD-BUS label. See Figure 4-5. Also, refer to Paragraph 4.8 for more information on parameters unique to the RAD-ISM-900-DATA-BD-BUS.

Note

If you force the program to a particular model of radio, and then attempt to download it to the wrong model, you will experience communication errors.

4.5.7 Baud Rate

This determines the speed at which the serial port on the radio sends data to the serial device connected to it. The radio and the serial device connected to its RS232/485/422 port must be the same. This baud rate is different and independent of the over-the-air data rate.

4.5.8 Data Bits

This determines how many bits will form each character of data. The radio and the serial device connected to its RS232/485/422 port must be the same. The majority of protocols use 8 data bits.

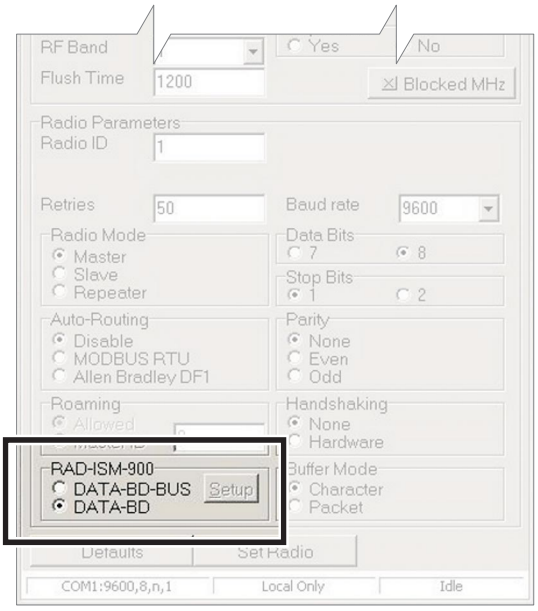


Figure 4-5. Setting RAD-ISM-900 Parameters

4.5.9 Stop Bits

This determines how many bits will be used to denote the end of a character. The radio and the serial device connected to its RS232/485/422 port must be the same. The majority of protocols use 1 stop bit.

4.5.10 Parity

A parity bit is a bit appended to the end of a character that is a crude error detection method. It will detect an error in a character only 66% of the time, so often is it not used. (This radio modem also uses CRC16 error checking which will catch errors 99.999% of the time). The radio and the serial device connected to its RS232/485/422 port must be the same. Most protocols use no parity.

4.5.11 Handshaking

Handshaking uses additional pins on the RS232 connector to ensure each device is ready to accept data before transmission begins. This is between the end serial device and the radio, not over the airwaves between two radios. The two pins are the RTS (ready-to-send) and the CTS (clear-to-send). The transmitting device asserts a voltage on the RTS pin, and when the receiving device is ready, it asserts a voltage on the CTS pin – and then data transmission begins. If handshaking is enabled on the radio, it must also be enabled on the end serial device. It only functions over the RS-232 port, not the RS485/422 port. Refer to Section 3 for information on the additional wires that are needed for the serial port cable.

Handshaking will prevent the buffer on the radio from over flowing when the serial port baud rate is faster than the over-the-air data rate. The radio's buffer size is 512 bytes, so hand-shaking should be used when messages exceed 512 bytes. Handshaking becomes more important at higher baud rates because of the difference between the over-the-air data rate and the serial port data rate.

4.5.12 Buffer Mode

The two options for buffer mode determine if the receiving radio buffers data before sending it out its serial port (packet) or if it sends each character out its serial port immediately after it arrives over the airwaves. The radio will break a message into smaller pieces, if the message exceeds 22 bytes for transmission over the airwaves. The radio can send 22 bytes of user data per hop. Therefore larger messages are divided up and sent on several hops. At the receiving radio this means the message arrives in 22 byte pieces. Most protocols use a gap in time to determine that the complete message has been received, and can then be processed. If this is the case, packet buffer mode must be selected. If the protocol uses a special symbol to denote the end of a message, then character buffer mode must be selected. Modbus and related protocols require packet mode. Allen Bradley's DF1 protocol requires character mode.

4.6 Saving and Loading Radio "Projects"

The Projects capability of the RadLink software allows users to store the configuration information of each radio to your computer and to use the Online Monitor function. This can be useful for troubleshooting or replacing a radio. The steps involve creating a new project and saving. Once the information has been saved, you can retrieve this data by loading from your computer. See Figure 4-6.

4.6.1 Creating a Radio Project

From the main menu, select "Project" and then "Create New Project…" Enter a file name and select "Save".

Enter all the parameters for each radio, and select "Save Radio". To program the next radio, select "New Radio", enter the parameters and select "Save Radio. The "New Radio" and "Save Radio" use the same button which toggles these functions.

To download each set of parameters to each radio, select "Set Radio"

4.6.2 Online Monitor Function

The Online Monitor allows a user to access basic "health" information of each slave radio through the master. When the master radio is connected to the computer running RadLink software, and a Project is loaded, the Online monitor will poll each slave radio and display the power supply voltage, RSSI and the internal temperature. To turn on the Online Monitor, simply select "Online Monitor" from the pull down menus. When a check mark appears, the Online Monitor has been turned on. Also, refer to Section 10 of this manual for more information on Online Monitor.

All of the radios in the network will appear on the right of your screen with their labels. If the radio symbol is red, it has not been polled or cannot be communicated with and

when it turns green it has been communicated with and values updated. The RSSI is displayed in –dB, the internal temperature in degrees Celsius and the power supply voltage in volts.

The Online Monitor can be used by connecting the PC running RadLink software to the primary or secondary (remote diagnostics) serial port. If serial communications are occurring through the primary port, the secondary port becomes the remote diagnostics port. The Online Monitor function will provide slower updates when data is being sent through both ports because the primary port has higher priority than the secondary or (remote diagnostics) port.

If using the secondary or remote diagnostics port, the port settings are fixed at 19,200 baud, N, 8 and 1 with no handshaking. The primary ports settings can be adjusted by the user.

Note – Specific to the RAD-ISM-900-DATA-BD-BUS

Online Monitor functions are not possible through the secondary or remote diagnostics port on this model. It is only possible through the primary port and therefore when no user data is being passed.

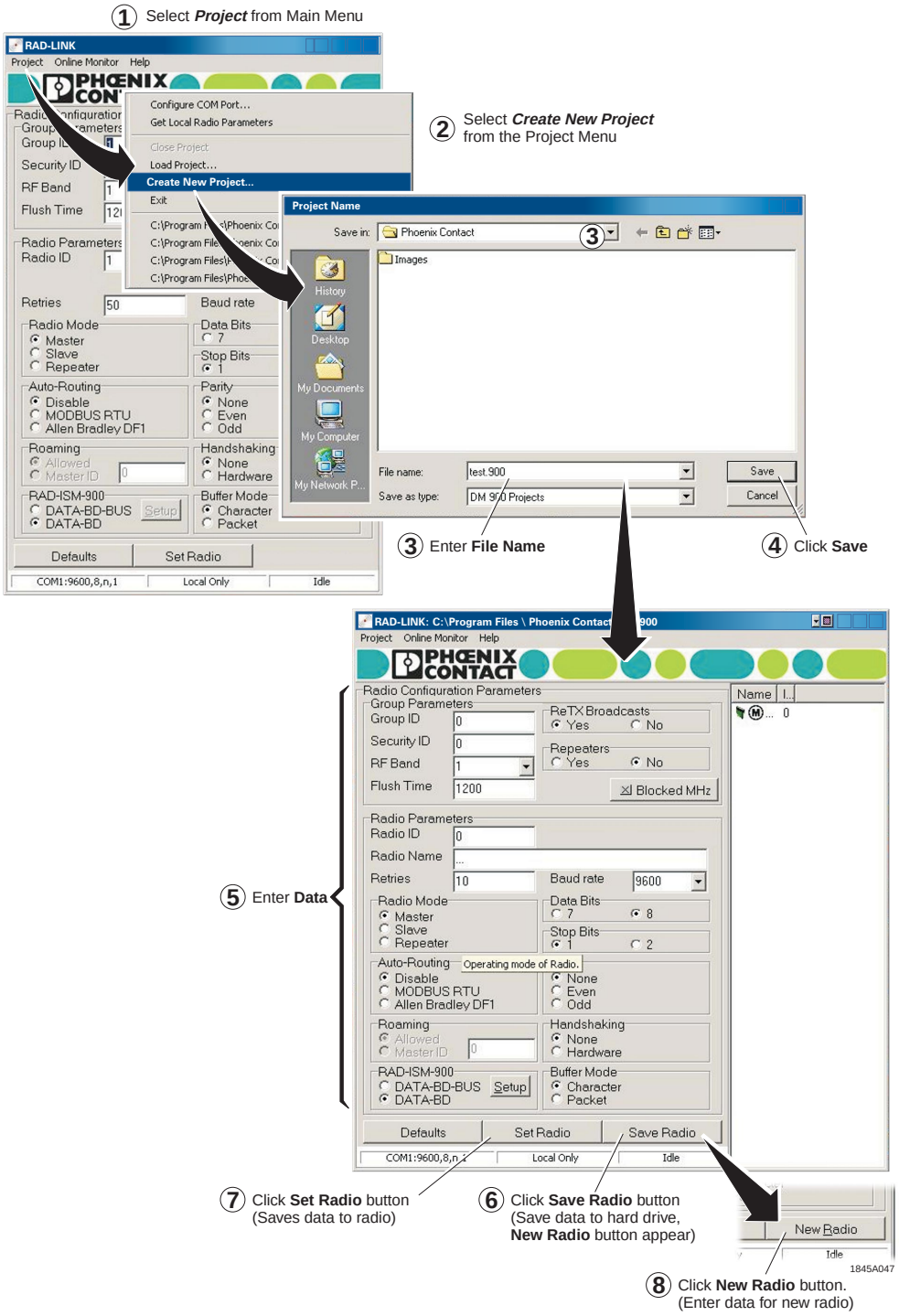


Figure 4-6. Saving & Loading Radio Projects

Note – Specific to the RAD-ISM-900-RS232-BD

On this radio the primary port is always the RS232 port with the 9-pin D connector. The remote diagnostics port is the mini-DIN connector on the side of the radio. A cable that adapts a 9-pin D connector the mini-DIN connector can be ordered, use part number 5605477. Alternatively, if you wish to build your own cable, the connections are shown in Figure 4-7.

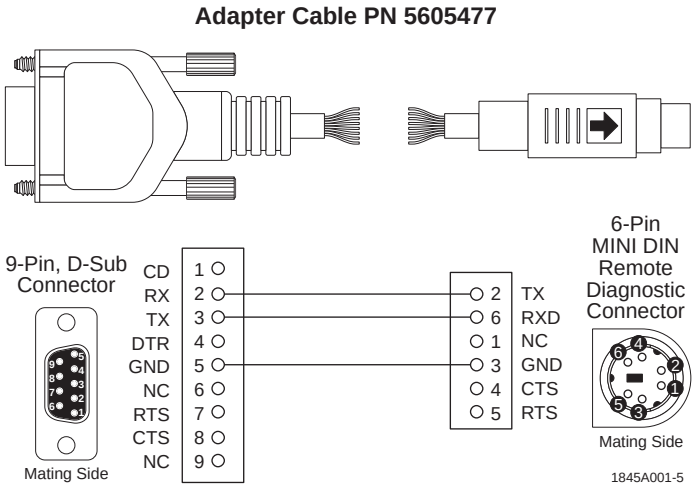


Figure 4-7. Cable Assembly PN 5605477

Note – Specific to the RAD-ISM-900-DATA-BD

With this radio, the user selects which port is to function as the primary port. See Figure 4-8. The other port automatically becomes the secondary or remote diagnostics port with fixed port settings of 19,200, N, 8 and 1. If the RS485/422 port is the secondary or remote diagnostics port, then the internal DIP switch #2 determines if it will function as RS485 or RS422.

Switch 1	RS232 Port	OFF
Switch 1	RS422/RS488	ON
Switch 2	2-wire half duplex	OFF
Switch 2	4-wire full duplex	ON
Switch 3	Not connected	
Switch 4	Not connected	

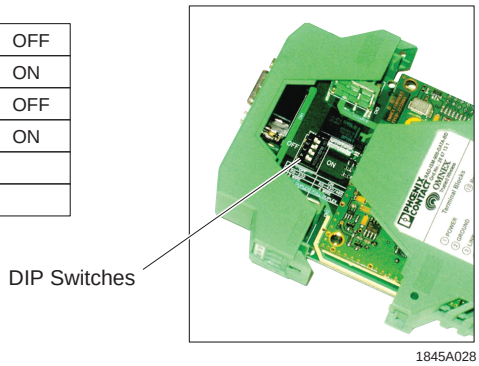


Figure 4-8. DIP-switch Settings for RS232, RS485 or RS422 Ports

4.7 Radio Parameters Specific to the RAD-ISM-900-DATA-BD

The only additional parameter unique to the RAD-ISM-900-DATA-BD radio is the selection of the primary serial port. The options are RS232, RS485 or RS422. The primary serial port is selected by internal DIP switches. By pressing in the indents on either side of the radio underneath the terminal blocks, the plastic housing can be removed to expose the DIP switches. Set the DIP switches according to the labels printed on the circuit board.

When one port has been selected as the primary serial port, all programming and data transfer occur through this port and the other port becomes the remote diagnostics port. Refer to Section 10 for more information on remote diagnostics. Note that if you wish to program the radio through the RS232 port, but wish to transfer data through the RS485 port, you should do all the programming first with the DIP switches set to RS-232 and then set the DIP switches to RS485/422.

4.8 Radio Parameters Specific to the RAD-ISM-900-DATA-BD-BUS

There are additional parameters only applicable to the RAD-ISM-900-DATA-BD-BUS radio. They are accessed by selecting the “Setup” button in the main menu just to the right of the DATA-BD-BUS selection. See Figure 4-9. When selected, the DATA-BD-BUS menu will appear.

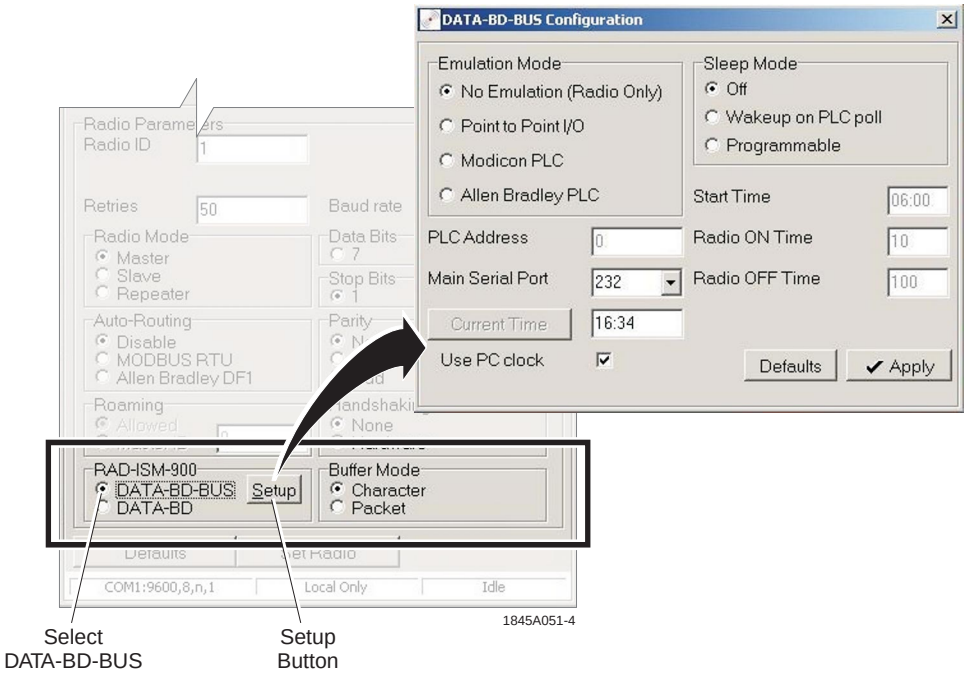


Figure 4-9. Setting Additional Parameters for the RAD-ISM-900-DATA-BD-BUS

4.8.1 Emulation Mode

There are four different modes the radio can operate in. Refer to Section 5 for a description of each mode. All radios in a network must have the same emulation mode.

4.8.2 PLC Address

If operating in either Modicon PLC or Allen Bradley Emulation Mode, you must assign a PLC address to all radios – master, slave and repeaters. All must have a different PLC address. Values range from 0 to 254.

4.8.3 Main Serial Port

Allows you to select either the RS232, RS485 or RS422 ports as the primary port. RS485 is a 2-wire, half-duplex standard, whereas, RS422 is a 4-wire, full-duplex standard. If the RS232 port is selected as the primary port, the RS485/422 port becomes the remote diagnostics port. Refer to Section 10 for more information on remote diagnostics.

Note

If you are programming the radio through its RS232 port but desire to send data through the RS485/422 port, you will need to select the RS232/RS422 port as your Main Serial Port, then download settings to the radio. However, once selected, you will no longer be able to program the radio through the RS232 port. If you need to make changes to the radio configuration through the RadLink software, you can either program it through the RS485/422 port or reset the radio so that the RS232 port is the Main Serial Port for programming and data transfer as described below.

a. Resetting the radio to make the RS232 port the Main Serial Port.

1. Remove the plastic housing from the radio.
2. Set Config 3, switch 1 to the ON position.
3. Ensure that all other switches are in the OFF position.
4. Apply power to the radio for 10 seconds and then remove power.
5. Set Config 3, switch 1 back to the OFF position and reinstall the plastic housing.
6. Program the radio through its RS-232 port as described below.

b. Programming the radio through the RS-232 port.

You can now program the radio through the RS232 port. However, some of the other configuration settings may have changed. Therefore, it is important to review all settings in the software before downloading them to the radio. The com port settings for the radio will likely be different from your previous settings. Therefore use the “Auto-Configure” capability to determine these settings, under the “Projects”, “Configure Com Ports…” dialog box. Refer to Paragraph 4.9 for more information on programming by DIP switches.

4.8.4 Sleep Mode

Radios programmed for slave operation can be put to “sleep” between polls to reduce power consumption. There are two different sleep modes, “Wake up on PLC Poll” and “Programmable”.

If **“Wake up on PLC Poll”** is selected, the radio remains powered on at all times, however it removes power from the I/O modules connected to it until that specific radio is polled by the PLC. Once it has been polled, it will apply power to the I/O modules connected to it for the amount of time specified in the “Radio ON Time”.

If **“Programmable”** sleep mode is selected, the radio and all I/O modules are put into a sleep mode. The radio then wakes up and powers itself and the I/O modules at the “Start Time”. This sleep mode will reduce power consumption further than is possible with the “Wake up on PLC Poll” method because power is also removed from the radio. A watch dog timer is still powered, so power should not be completely removed from the radio. However an on-board battery will provide power to the timer but cannot power the radio.

Note

The radio cannot be communicated with or programmed when it is "asleep".

When using the “Programmable” sleep mode, the start time, relative to the Current Time or PC clock, determines when the radio goes back to full power mode and can respond to PLC polls. The radio will remain in full power mode until the “On Time” has elapsed. At this point the “Off Time” begins and the radio will remain off until the time entered has elapsed. The radio will continue to cycle ON and OFF until the next "Start Time”. At that point the cycle will reset and begin again.

Select the "Apply" button to return to the main menu. Selecting the "Defaults" button will reset all values in the submenu back to their factory default settings.

Select “Set Radio” to download all parameters to the radio.

4.9 Configuration using DIP Switches (RAD-ISM-900-DATA-BD-BUS only)

As an alternate to configuration using the RadLink software, limited configuration can be done using the internal DIP switches. See Figure 4-10. To access the DIP switches, press the indents in on either side of the plastic housing just below the terminal blocks and slide down the plastic housing. With power removed from the radio, adjust the DIP switches accordingly. Refer to Paragraphs 4.4, 4.5 and 4.8 for more information on the operation of each parameter.

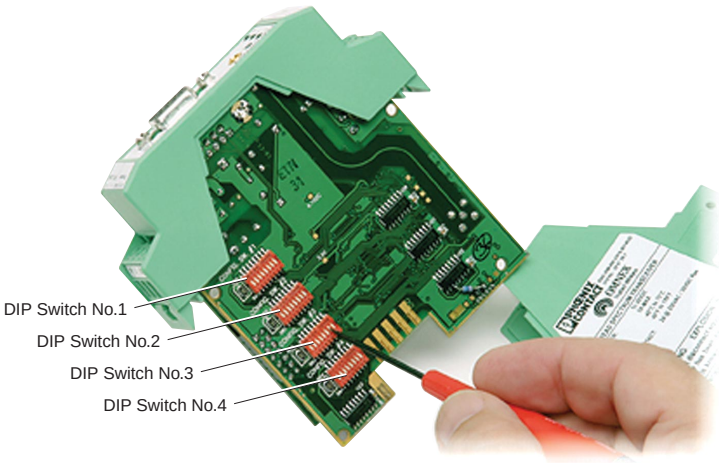
The following parameters cannot be accessed if you are configuring the radio by DIP-switches:

- Security ID
- Flush Time
- Re TX Broadcasts
- Repeaters
- Blocked MHz
- Retries
- Auto-Routing
- Roaming
- Baud rates other than 1200, 4800, 9600 and 19,200
- Sleep Modes

DIP Switch No. 1 Settings							
SW1	SW2	Function					
OFF	OFF	Radio ID 1					
OFF	ON	Radio ID 2					
ON	OFF	Radio ID 3					
ON	ON	Radio ID 4					
SW3	SW4	SW5	SW6	SW7	SW8	Function	
Randomly set to any configuration							

DIP Switch No. 2 Settings							
SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
Randomly set to any configuration							

DIP Switch No. 3 Settings		
SW1	Function	
ON	overrides software of AT commands	
ON	software or AT command configuration	
SW2	Function	
ON	RS485	
OFF	RS232	
SW3	SW4	Function
OFF	OFF	master radio mode
OFF	ON	slave radio mode
SW5	Function	
ON	PLC emulation mode	
OFF	radio modem mode	
SW6	Function	
ON	8 data bits , no parity, one stop bit	
OFF	7 data bits, even parity, one stop bit	
SW7	SW8	Function
OFF	OFF	1200 Baud Rate
OFF	ON	2400 Baud Rate
ON	OFF	9600 Baud Rate
ON	ON	19200 Baud Rate



DIP Switch No.4 Settings							
If DIP Switch 3, Position 5 is **ON**							
SW1	Function						
ON	Allen Bradley Emulation						
OFF	Modicon Emulation						
SW2	SW3	SW4	SW5	SW6	SW7	SW8 (LSB)	
PLC Node Address							

If DIP Switch 3, Position 5 is **OFF**						
SW1	SW2	SW3	SW4	SW5	SW6	
Reserved						
SW7	Function					
ON	packet buffer mode					
OFF	character buffer mode					
SW8	Function					
ON	point-to-point I/O mode					
OFF	point-to-multi-point mode					

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Figure 4-10. Setting Additional Parameters for the RAD-ISM-900-DATA-BD-BUS

Note

Since some parameters cannot be adjusted using the DIP switches, if you have begun programming and set some parameters using the RadLink software, then revert to programming using the DIP switches, you may experience configuration difficulties. For example, if the master radio is programmed with a security ID other than the factory default, and the slave radio is programmed using the DIP switches, they will not be able to communicate with each other because the security ID's will not match. In this scenario, you could either use the RadLink software to set the master radio's security ID back to the factory default value or, use the RadLink software to program the slave radio.

SECTION 5

DATA-BUS Configuration for I/O Modules (RAD-ISM-900-DATA-BD-BUS Only)

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5.1 I/O Module Descriptions

There are 5 different I/O modules that can be used with the RAD-ISM-900-DATA-BD-BUS radio. See Figure 5-1. They are powered from the radio through the 5-pin male/female connector on either side of the radio and I/O module. They feature an 8-position rotary switch on the top of each module for addressing.

1. Analog Input Module – RAD-IN-4A-1

This module has four (4) 0-22mA current inputs. It can either accept powered loops or provide the power for a loop. The power supply for the loops is common to the radios power supply.

2. Analog Output Module – RAD-OUT-4A-1

This module has four (4) 0-22mA current outputs. It can either accept powered loops or provide the power for a loop. Each current loop is optically isolated from each other. Internally there are 4 DIP switches that determine what happens to each current channel if the radio link is lost – either fail to 2mA or maintain the last known value.

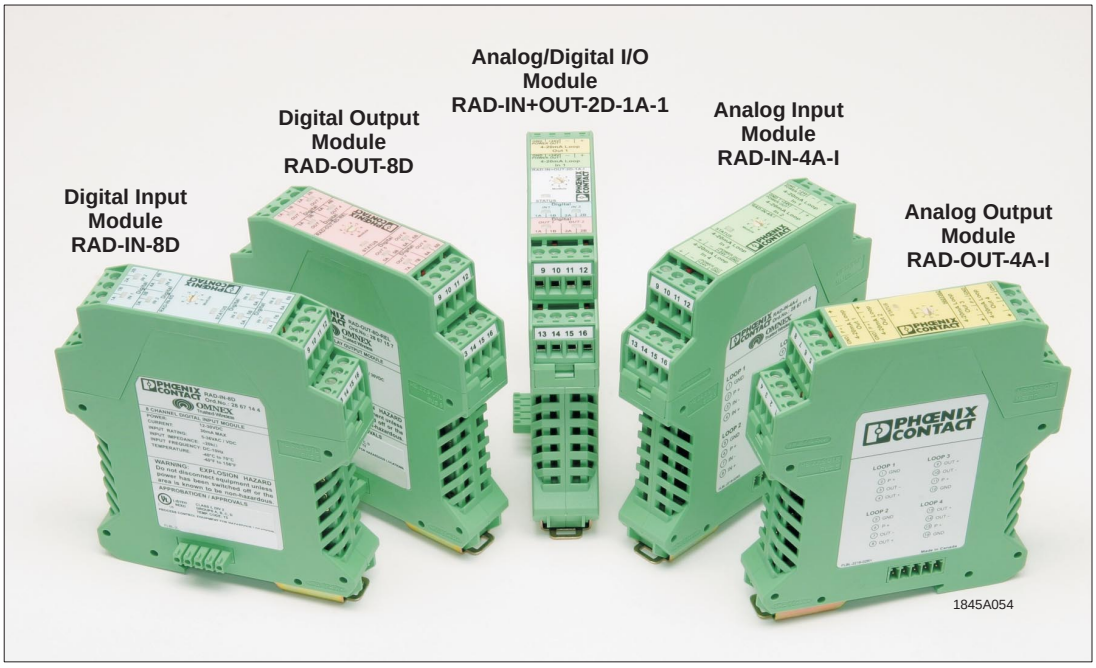

Figure 5-1. I/O Modules Uses with the RAD-ISM-900-DATA-BD-BUS

3. Digital Input Module – RAD-IN-8D

This module has eight (8) digital inputs. Each input requires a voltage to trigger it. Each channel is optically isolated.

4. Digital Output Module – RAD-OUT-8D

This module has eight (8) digital outputs. Each output is a normally open dry contact. Internally there are 8 DIP switches that determine what happens to each channel if the radio link is lost – either fail open or maintain the last known value.

5. Analog/Digital I/O Module – RAD-IN+OUT-2D-1A-1

This module has a mix of inputs and outputs – 1 analog input, 1 analog output, 2 discrete inputs and 2 discrete outputs. Internally there are DIP switches that determine the fail condition of the outputs in a similar fashion as described in the above modules.

5.2 Point-to-Point Emulation Mode

In this mode of operation, the radio can exchange 4-20mA and discrete signals. When a current signal is applied to one radio, its exact value is replicated at the remote radio, and similarly with discrete signals. In point-to-point emulation mode, there can be only one master radio and only one slave radio. Each radio must have I/O modules connected to it. The I/O modules must be used in pairs, and complimentary to each other. For example, if three analog input modules are connected to one radio, the other radio must have three analog output modules connected to it. It is possible to send data through the RS232 or RS485/422 ports of the radio. However, the analog/discrete I/O will take priority, thereby cutting the serial data throughput approximately in half.

There is an eight position rotary switch on the top of each I/O module. See Figure 5-2. Each I/O module connected to a radio must have a different rotary switch setting, and it must match the complimentary module on the opposite end. A maximum of eight I/O modules can be connected to each radio.

5.2.1 Programming the radios for Point-to-Point Emulation Mode

1. Connect the radio to your computer's serial port and apply power to the radio.
2. Run the RadLink software
3. Program the settings common to all DATA series radios. See Section 4.0 for additional information.
4. Under RAD-ISM-900, select "DATA-BD-BUS" and select "Setup".
5. Under Emulation Mode, select "Point-to-Point I/O" and select "Apply".
6. Select "Set Radio" to download these settings to the radio.
7. Repeat steps 1-6 with the second radio.

5.2.2 Connecting and Configuring the I/O modules

1. Remove the plastic housing from the output modules and set the fail condition DIP switches as desired for each channel. Refer to Paragraph 5.6 for more details.
2. Connect the I/O modules and radio to the DIN-rail and slide them together so the 5-pin male/female connectors mate.
3. Set the 8-position rotary switch on the I/O modules so that each I/O module matches its complimentary module on the opposite radio. Refer to Paragraph 5.2.
4. Wire the analog and discrete signals. Refer to Paragraph 5.5. Next, connect the antenna and apply power. Refer to Sections 3 and 9.

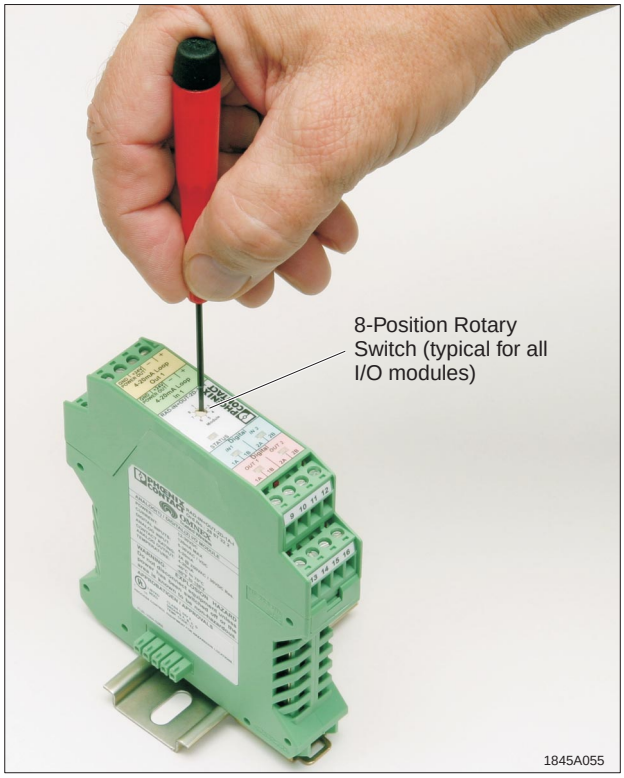

Figure 5-2. I/O Modules 8-Position Rotary Switch

5.3 No Emulation Mode of Operation

In this mode of operation, the RAD-ISM-900-DATA-BD-BUS radio operates in the exact same fashion as the RAD-ISM-900-RS232-BD and the RAD-ISM-900-DATA-BD. That is, it will allow the transfer of serial data through its RS232 or RS485/422 port. There can be only one master and up to 254 slave radios. When data is sent into the master radio, it appears on the serial port of all slave radios. The devices connected to the RS232/485/422 port of each slave must be able to read the address associated with the command and only respond it matches their internal address. Every device must have a different address programmed into it. No analog or digital signals can be applied to the radio and no I/O modules can be connected.

5.3.1. Configuring the radio for "No Emulation" (Radio Modem Operation)

1. Connect the radio to your computer's serial port and apply power to the radio.
2. Run the RadLink software.
3. Program the settings common to all DATA series radios. Refer to Section 4 for details)
4. Under RAD-ISM-900, select "DATA-BD-BUS" and select "Setup".
5. Under Emulation Mode, select "No Emulation".
6. Under Main Serial Port, select the desired port you wish to transfer data through.
7. Select "Apply", and select "Set Radio" to download the parameters to the radio.
8. Repeat steps 1-6 with all subsequent radios.

Note

If you are programming the radio through its RS232 port but wish to send data through the RS485/422 port, after you select this port as your Main Serial Port and download these settings to the radio, you will no longer be able to program it through the RS232 port. If you need to make changes to the radios configuration through the RadLink software, you can either program it through the RS485/422 port OR follow this procedure to reset the radio so the RS232 port is the Main Serial Port for programming and data transfer:

9. Remove the plastic housing from the radio.
10. Set Config 3, switch 1 to the ON position.
11. Ensure that all other switches are in the OFF position.
12. Apply power to the radio for 10 seconds and then remove power.
13. Set Config 3, switch 1 back to the OFF position and reinstall the plastic housing. The radio can now be programmed through its RS-232 port.

Some of the other configuration settings may be changed, so it will be important to review all settings in the software before downloading them to the radio. The com port settings for the radio will likely be different from your previous settings. Therefore use the "Auto-Configure" capability to determine these settings, under the "Projects", "Configure Com Ports…" dialog box. Refer to Section 4 for more information on programming by DIP switches.

5.4 PLC Emulation Mode of Operation

PLC Emulation refers to each slave transceiver emulating either an Allen Bradley (AB) Micrologix PLC or a Modicon PLC. Specifically, the transceivers will understand commands in either DF1 protocol for AB or Modbus RTU protocol for a Modicon PLC. In this mode, the master PLC controls all commands and initiates all requests for data. The master PLC does not realize that it is communicating with a radio, as the radio simulates a slave PLC. See Figure 5-3. Analog and Discrete I/O module(s) need to be connected to each slave transceiver. The analog/discrete values are represented as registers. By using a request command (Modbus) or a message instruction (AB), you can read and write to registers on each slave radio. Optionally, a PLC could be connected to a slave radio, such that some slaves could have I/O modules connected, whereas others could have slave PLCs connected. Each radio and/or PLC must have a different PLC address. A PLC address can be programmed into each slave radio through the RadLink software or by DIP switches. A slave radio can also function as a repeater for a more distant slave radio(s).

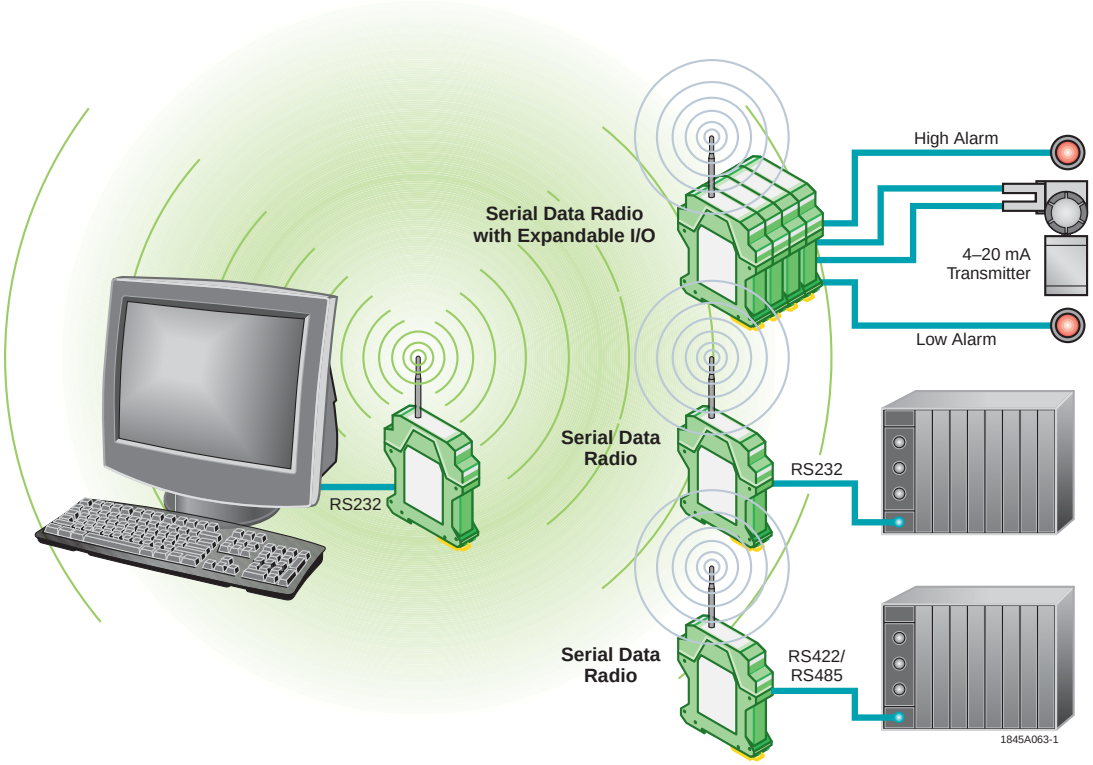

Figure 5-3. Configuration Showing Master PLC, Master Radio, and Master Radio with Expansion I/O

5.4.1 Configuring the radio for PLC Emulation Mode

1. Connect the radio to your computer's serial port and apply power to the radio.
2. Run the RadLink software.
3. Program the settings common to all DATA series radios (see section 5.0 for details)
4. Under RAD-ISM-900, select "DATA-BD-BUS" and select "Setup".
5. Under Emulation Mode, select either Modicon PLC or Allen Bradley PLC.

6. Assign a PLC address to the radio under “PLC Address”.
7. If a serial device will be connected, set the Main Serial Port.
8. If sleep mode is desired, enable it and enter the parameters applicable to its operation (see section 5.4)
9. Select “Apply” and select “Set Radio” to download these parameters to the radio.
10. Repeat steps 1-9 with all subsequent radios.

5.5 Addressing the Remote I/O

5.5.1 Address Maps

Each slave radio must have a unique PLC address programmed into it. Plugged into each slave, I/O modules have their analog/discrete inputs and outputs mapped to registers. When a command from the master PLC is broadcast through the master radio to all slave radios, they read the address to determine if they should respond. Within each command will be a read or write request to certain registers. Table 5-1 (Modbus) and Table 5-2 (Allen-Bradley) below are address maps that correlate each I/O channel to a Modicon or Allen Bradley register.

Note

The initial registers show the RSSI, internal temperature and power supply voltage. The RSSI is presented as a positive number. Add the negative sign to determine the RSSI in –dB. For example if 67 is the value in decimal in the register, the RSSI is -67 dB. If a value of –151dB is shown there is no radio link. The value for the master radio is the average of all the slaves polled. The internal temperature is expressed in degrees Celsius and the power supply voltage in volts.

Table 5-1. MODBUS Memory Map

	0	10000	40000
1	Reserved	Reserved	RSSI
2	Reserved	Reserved	Power Supply Voltage
3	Reserved	Reserved	Temperature
4-16	Reserved	Reserved	Reserved
17-24	Module #1 digital outputs	Module #1 digital inputs	Module #1 analog inputs
25-32	Reserved	Reserved	Module #1 analog outputs
33-40	Module #2 digital outputs	Module #2 digital inputs	Module #2 analog inputs
41-48	Reserved	Reserved	Module #2 analog outputs
49-56	Module #3 digital outputs	Module #3 digital inputs	Module #3 analog inputs
57-64	Reserved	Reserved	Module #3 analog outputs
65-72	Module #4 digital outputs	Module #4 digital inputs	Module #4 analog inputs
73-80	Reserved	Reserved	Module #4 analog outputs
81-88	Module #5 digital outputs	Module #5 digital inputs	Module #5 analog inputs
89-96	Reserved	Reserved	Module #5 analog outputs
97-104	Module #6 digital outputs	Module #6 digital inputs	Module #6 analog inputs
105-112	Reserved	Reserved	Module #6 analog outputs
113-120	Module #7 digital outputs	Module #7 digital inputs	Module #7 analog inputs
121-128	Reserved	Reserved	Module #7 analog outputs
129-136	Module #8 digital outputs	Module #8 digital inputs	Module #8 analog inputs
137-144	Reserved	Reserved	Module #8 analog outputs
145	Reserved	Reserved	Reserved
146	Reserved	Reserved	Reserved
147	Reserved	Reserved	Module #1 digital inputs
148	Reserved	Reserved	Module #1 digital outputs
149	Reserved	Reserved	Module #2 digital inputs
150	Reserved	Reserved	Module #2 digital outputs
151	Reserved	Reserved	Module #3 digital inputs
152	Reserved	Reserved	Module #3 digital outputs
153	Reserved	Reserved	Module #4 digital inputs
154	Reserved	Reserved	Module #4 digital outputs
155	Reserved	Reserved	Module #5 digital inputs
156	Reserved	Reserved	Module #5 digital outputs
157	Reserved	Reserved	Module #6 digital inputs
158	Reserved	Reserved	Module #6 digital outputs
159	Reserved	Reserved	Module #7 digital inputs
160	Reserved	Reserved	Module #7 digital outputs
161	Reserved	Reserved	Module #8 digital inputs
162	Reserved	Reserved	Module #8 digital outputs

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MODBUS Register Addressing
Config Switch No.4, Switch N0. 1 = OFF

Table 5-2. Allen-Bradley Memory Map

Address	Description
B3:0/0-15	Reserved
B3:1/0-15	Reserved
B3:2/0-15	Module #1 digital inputs
B3:3/0-15	Module #1 digital outputs
B3:4/0-15	Module #2 digital inputs
B3:5/0-15	Module #2 digital outputs
B3:6/0-15	Module #3 digital inputs
B3:7/0-15	Module #3 digital outputs
B3:8/0-15	Module #4 digital inputs
B3:9/0-15	Module #4 digital outputs
B3:10/0-15	Module #5 digital inputs
B3:11/0-15	Module #5 digital outputs
B3:12/0-15	Module #6 digital inputs
B3:13/0-15	Module #6 digital outputs
B3:14/0-15	Module #7 digital inputs
B3:15/0-15	Module #7 digital outputs
B3:16/0-15	Module #8 digital inputs
B3:17/0-15	Module #8 digital outputs

Address	Description
N7:0	RSSI
N7:1	Power Supply Voltage
N7:2	Temperature
N7:3-15	Reserved
N7:16-23	Module #1 analog inputs
N7:24-31	Module #1 analog outputs
N7:32-39	Module #2 analog inputs
N7:40-47	Module #2 analog outputs
N7:48-55	Module #3 analog inputs
N7:56-63	Module #3 analog outputs
N7:64-71	Module #4 analog inputs
N7:72-79	Module #4 analog outputs
N7:80-87	Module #5 analog inputs
N7:88-95	Module #5 analog outputs
N7:96-103	Module #6 analog inputs
N7:104-111	Module #6 analog outputs
N7:112-119	Module #7 analog inputs
N7:120-127	Module #7 analog outputs
N7:128-135	Module #8 analog inputs
N7:136-143	Module #8 analog outputs
N8:0/0-15	Reserved
N8:1/0-15	Reserved
N8:2/0-15	Module #1 digital inputs
N8:3/0-15	Module #1 digital outputs
N8:4/0-15	Module #2 digital inputs
N8:5/0-15	Module #2 digital outputs
N8:6/0-15	Module #3 digital inputs
N8:7/0-15	Module #3 digital outputs
N8:8/0-15	Module #4 digital inputs
N8:9/0-15	Module #4 digital outputs
N8:10/0-15	Module #5 digital inputs
N8:11/0-15	Module #5 digital outputs
N8:12/0-15	Module #6 digital inputs
N8:13/0-15	Module #6 digital outputs
N8:14/0-15	Module #7 digital inputs
N8:15/0-15	Module #7 digital outputs
N8:16/0-15	Module #8 digital inputs
N8:17/0-15	Module #8 digital outputs

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AB's DF1 Register Addressing
(Config Switch No.4, Switch N0. 1 = ON)

5.5.2 Rotary Switches

On the top of each I/O module is an 8-position rotary switch. See Figure 5-4. In the address maps above there are references to module numbers. These module numbers refer to the position of the rotary switch. Each module must have a different number.

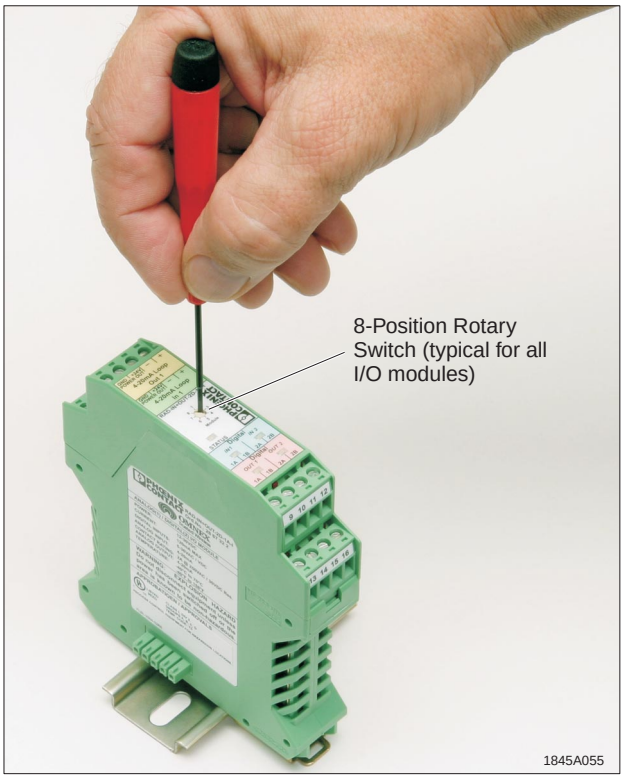

Figure 5-4. I/O Modules 8-Position Rotary Switch

5.5.3 Register Scaling

a. Digital Channels

A digital output channel can be turned on by writing a “1” to the digital output register, and off by writing a “0” to the output register.

b. Analog Channel Scaling

Analog channels are scaled as follows:

$$\text{Current Input} = \frac{(\text{Register Value}) \bullet 22\ \text{mA}}{32{,}767}$$

$$\text{Current Output} = \frac{(\text{X mA} \bullet 32{,}767)}{22\ \text{mA}}$$

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5.6 Wiring and Fail Condition DIP Switches for the I/O Modules

5.6.1 Analog Input Module

If using the Analog Input Module, use the wiring diagram shown in Figure 5-5.

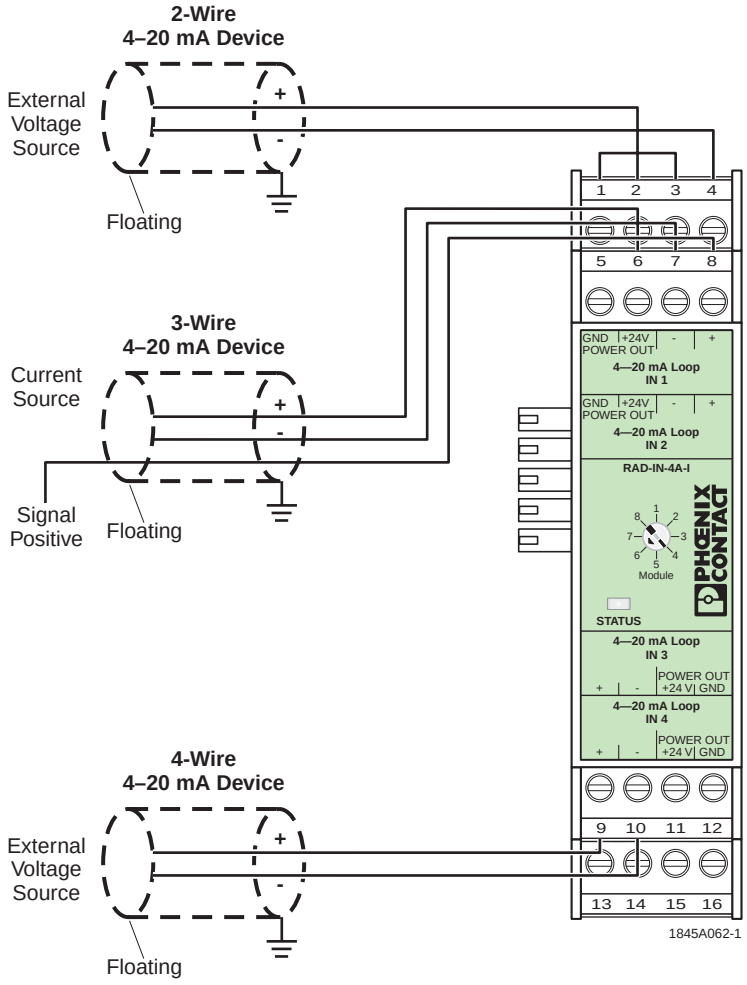

Figure 5-5. Wiring Diagram Using RAD-IN-4A-I Analog Input Module

5.6.2 Discrete Input Module

If using a Digital (Discrete) Input Module, use the wiring diagram shown in Figure 5-6.

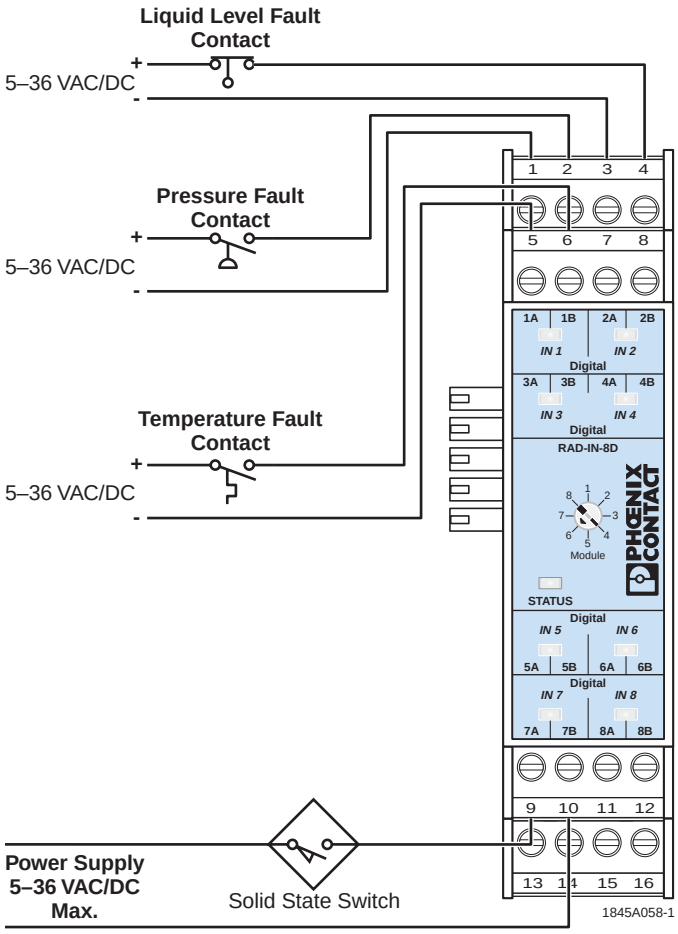

Figure 5-6. Wiring Diagram Using RAD-IN-8D Digital Input Module

5.6.3 Analog Output Module

If using the Analog Output Module, use the wiring diagram shown in Figure 5-7.

Inside of the Analog Output Module are DIP switches that allow the user to determine the status of each channel if the RF link is lost. The options are Maintain Last State or Fault off, to a current value of approximately 2mA. By releasing the top part of the housing, you can access the internal DIP switches.

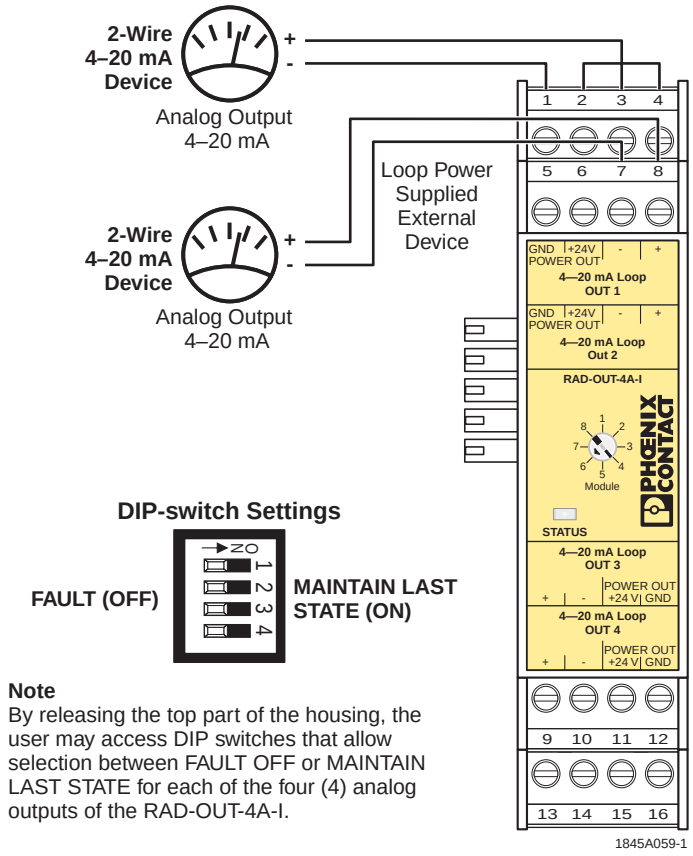

Figure 5-7. Wiring Diagram Using RAD-OUT-4A-I Analog Output Module

5.6.4 Digital Output Module

If using the Digital Output Module, use the wiring diagram shown in Figure 5-8.

Inside of the Digital Output Module are DIP switches that allow the user to determine the status of each channel if the RF link is lost. The options are Maintain Last State or Fault Off (open circuit). By releasing the top part of the housing, you can access the internal DIP switches.

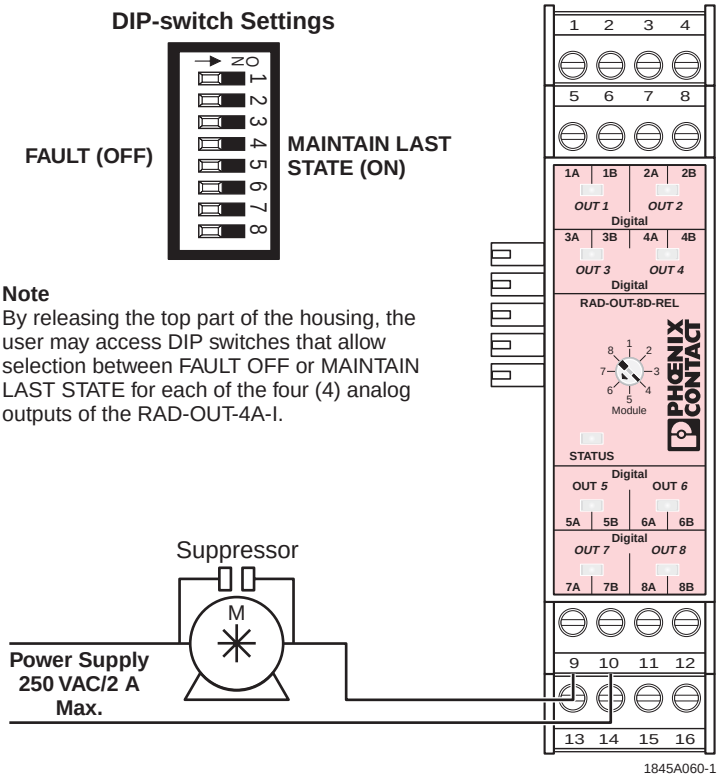

Figure 5-8. Wiring Diagram Using RAD-OUT-8D-REL Digital Output Module

5.6.5 Combination Input/Output Module

If using the Combo Module, use the wiring diagram shown in Figure 5-9.

Inside of the Combo Module are DIP switches that allow the user to determine the status of each channel if the RF link is lost. The options are Maintain Last State or Fault Off (open circuit). By releasing the top part of the housing, you can access the internal DIP switches.

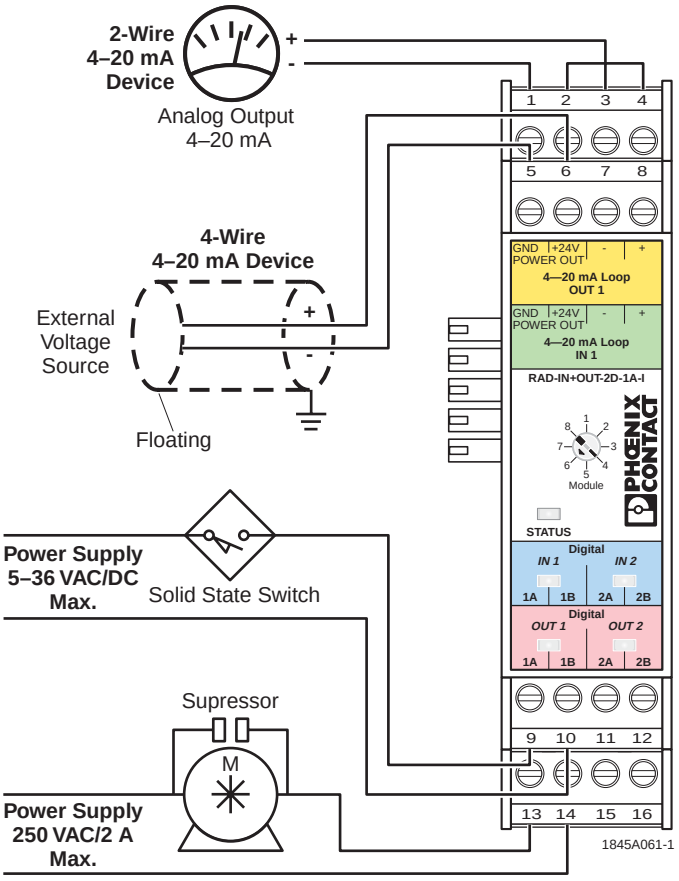

Figure 5-9. Wiring Diagram Using RAD-OUT-8D-REL Digital Output Module

5.7 Troubleshooting a RAD-ISM-900-DATA-BD-BUS Module in PLC Emulation Mode

In order to troubleshoot the system efficiently, place all radios and end devices on a bench, such that they are all within 10 feet of each other and disconnect any antennas. See Table 5-3 for a list of problems along with the action required to solve the problems.

Table 5-3. RAD-ISM-900-DATA-BD-BUS Troubleshooting Chart

Problem	Solution
No radio communications (bench test – radios no more than 10 feet apart)	1. No radio communications (bench test – radios no more than 10 feet apart)1)Ensure the Group ID, Security ID, RF Band, Re TX Broadcast, Repeaters and Blocked MHz are the same on all radios. 2. Ensure each radio has a different Radio ID. 3. Ensure there is only 1 master in the network. 4. If “Roaming” is not allowed, ensure the correct ID for the master radio is entered.
Radio Link drops out every 2 seconds (approximately)	1. Check to see that the Blocked MHz are the same on all radios.
Unable to communicate with master radio (TX LED does not flash when master PLC sends command)	1. Check com port settings – radio to PLC must match each other. 2. If using RS-232, swap a straight through cable for a null modem or vice versa. Look to see that the TX LED is on solid (correct cable indicator). 3. If using RS485/422, ensure TX+ is connected to RX+ and TX- to RX-, etc.
Slave receives data but does not respond (RX LED on master does not flicker)	1. Check the PLC address of the command. 2. On the PLC, check that the error checking is set for CRC, half duplex communications, Modbus RTU or AB DF1 protocol.
Master radio receives data (RX LED flashes, but PLC gives error message	1. Increase message response timeout on the PLC. 2. Check the registers being polled to ensure they are supported. 3. Check the rotary switch on each I/O module and ensure no two are set the same. 4. Check the buffer mode (Packet required for Modbus, Character for DF1).
Communications OK but values not updating or inaccurate	1. Check the registers being polled (for most Modbus software, subtract 40,000 from the register number you are requesting to access the 40,000 registers, etc). 2. Check which device is powering current loops – either the I/O modules can power the loops or they can accept a powered loop.
Able to program up to register 100, then gives error message “Unable to Contact Radio…”	1. Attempting to program the radio as a DATA-BD. Select DATA-BD-BUS.

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SECTION 6
Radio Troubleshooting

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6.1 Status LED Indicators

On the top of each radio, there are 3 LED's, TX, RX and RF Link. See Figure 6-1. The RF Link LED indicates the status of the radio link. The TX and RX LED's indicate activity on the RF port.

Note

Applicable to the RAD-ISM-900-DATA-BD-BUS only: This radio has a 4th LED that is visible by viewing down the RSSI test point. This LED will be ON continuously under normal operation and will flash once every two seconds if the radio is in "sleep" mode. The radio cannot be programmed or exchange data when in "sleep" mode.

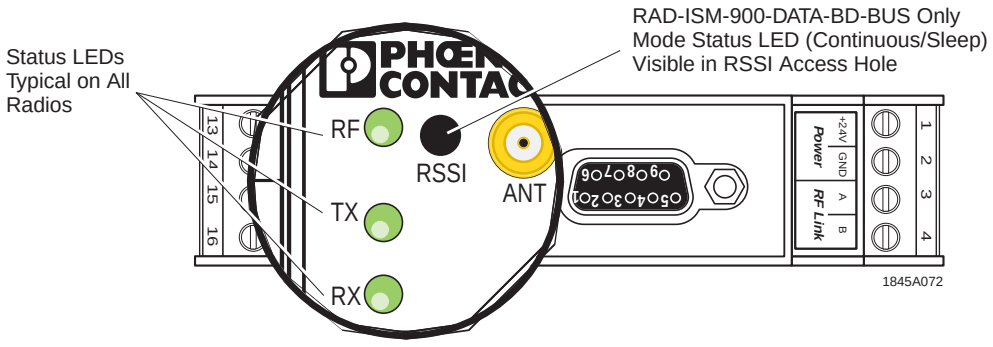

Figure 6-1. Typical Radio LED Status Indicators for

6.1.1 RF Link LED

When a radio is programmed as a master, the RF link LED will be ON solid green at all times, regardless of whether it has a radio link with any slaves. See Table 6-1. A slave radios RF link LED will flash slowly (once every 2 seconds) if it has not established a RF link with its master (or repeater). It will go solid green when the RF link has been established.

Table 6-1. RF Link LED Status

RF Link LED	Radio Mode		
	Master	Repeater	Slave
OFF	No power	No power	No power
Flashing Slowly	NA	Not linked to master	No RF linl
5 Quick Flashes	Illegal Group ID – factory default condition		
ON Solid	Power applied	RF link to master estab-lished	Power applied

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6.1.2 TX LED

The TX (transmit) LED reflects activity on the RF port (antenna). This LED also indicates when you have the correct cabling between the serial device and the radio. See Table 6-2. For example, on the RS232 port you can use a “straight through” 9-pin cable or a “null modem” 9-pin cable. When the correct cable is plugged in, power applied to the radio and the serial port on the computer/PLC/end device active, this LED will turn on solid. It will then flicker rapidly when data is being transmitted on the RF port.

Table 6-2. TX LED Status

TX LED	Description
OFF	(1) Improper cabling to the serial port. (2)nothing connected to serial port
Flickering Rapidly*	Data being transmitted on the RF port
ON Solid	Correct cabling between radio and serial device, but no data being transmitted

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***Note:** Applicable to the RAD-ISM-900-DATA-BD-BUS only: On a slave radio the TX LED will not flicker rapidly when a slave radio is transmitting data back to a master/repeater AND there is nothing connected to the RS232/485/422 port. This is because the TXD (pin 2)/TX (terminal on the RS485/422) on the serial port is used to trigger the LED.

6.1.3 RX LED

The RX (receive) LED indicates the radio is receiving data on its RF port (antenna). When data is being received over the air, this LED will flicker rapidly. See Table 6-3. Otherwise, it will remain on solid.

Table 6-3. RX LED Status

RX LED	Description
OFF	No power applied to radio
Flickering Rapidly*	Data being received by the radio
ON Solid	Power applied, no data being received

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6.2 Received Signal Strength Indicator (RSSI)

The RSSI test point will provide you with a measure of how strong the received radio signal is at each slave radio and at any repeaters. See Figure 6-2. There is no RSSI on the master radio since there is no indication of which slave it is communicating with. The RSSI is a voltage output, ranging from 0-3.5VDC. The positive connection for your multimeter is made on the top of the radio and the negative connection on the power supply ground. An adapter is available that will connect to the RSSI connector to allow permanent monitoring of the RSSI voltage (part numbers 0201744 for test connector and 0201663 for insulating sleeve)

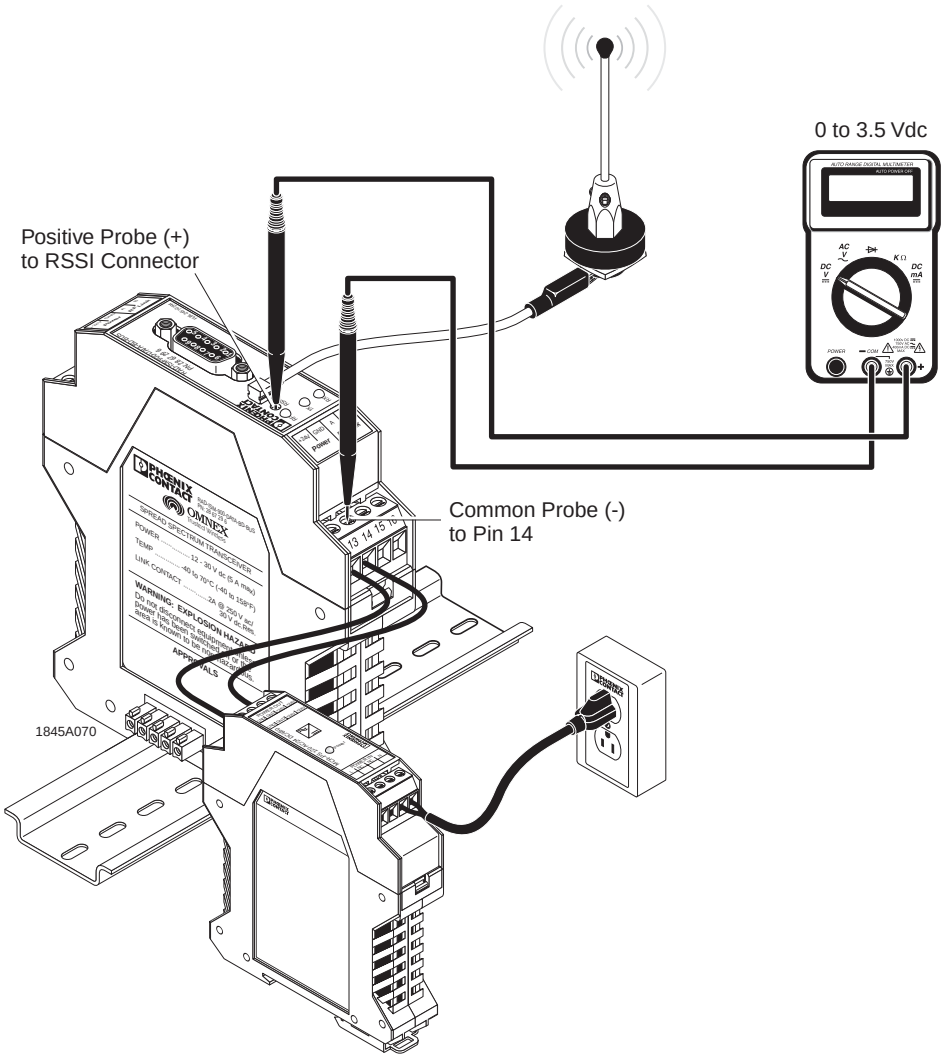

Figure 6-2. Voltage Measurement of the RSSI Test Port

The voltage measured directly correlates to the received signal expressed as –dB. Refer to Figure 6-3 below to determine the –dB from the voltage measured. Note that this voltage will constantly fluctuate due to multi-pathing.

The minimum recommended signal is 2.5VDC (-90dB). This will allow for approximately a 20dB fade margin to ensure communications in the event of deteriorating RF conditions.

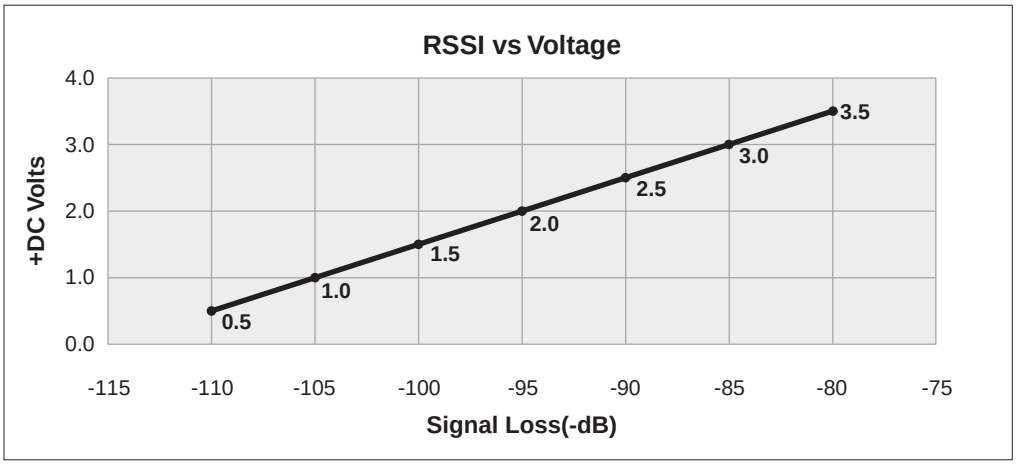

Figure 6-3. RSSI Voltage vs Received Signal

6.2.1 Reading the RSSI as a Register Value – Unique to the RAD-ISM-900-DATA-BD-BUS

The RSSI can be read through a register when in PLC Emulation Mode using either AB's DF1 protocol or Modbus RTU protocol. Refer to the Address Map in Section 5 for more information. The value stored in the register will directly reflect the signal strength in dB except for the negative sign. For example, if the value in the register is 80, that would mean the RSSI is –80dB.

6.2.2 Reading the RSSI through the RadLink Software

The RSSI of each slave radio can be read by connecting to the master radio and running the RadLink software. You must either "Create New Project…" or if an existing project has already been created, you can "Load Project…". Both options are located under the "Project" pull down menu. Refer to Section 4 for more information. The RSSI value of each slave radio will be shown, along with the power supply voltage and the internal temperature.

6.2.3 Reading the RSSI using AT Commands (locally)

The RSSI of a slave radio can be measured by connecting a PC directly to the slave. If a serial device is connected to the main serial port, then by connecting to the other serial port (remote diagnostics port), you can determine the RSSI. Refer to Section 10 for more information on using AT commands and reading the "S" registers.

6.2.4 Reading the RSSI using AT Commands (Remotely)

The RSSI of a slave radio can be measured by connecting a PC to the master radio's remote diagnostic port. Using AT commands in a terminal program, you can establish communications with a slave, and then query its S registers. Refer to Section 10 for more information on using AT commands.

6.3 General Troubleshooting

When troubleshooting a network, the first step is to ensure there is a good radio signal. Once that has been established, then check the wiring between the radio and serial devices so that you can program and send commands to the radio. After the wiring has been verified, then you can adjust the programming settings using the RadLink software.

The most practical method of troubleshooting a system is to lay all of the components out on a table, such that all radios are within 10 feet. This way there will be a strong radio link and programming each radio will not involve traveling to a remote site.

As a rule of thumb, disable the “Auto-Routing” feature during initial system commissioning, as this may cause problems as radio ID’s and device addresses are changed. Table 6-4 provides a list of possible problems as their solutions.

Table 6-4. General Troubleshooting

Problem	Solution
Unable to program radio (using RADLink software)	1. Ensure power is applied to radio 2. Ensure correct serial cable is being used (straight through for the RS232 port – TX LED will be on when correct cable connected) 3. Install driver if a USB to serial adapter cable is being used. 4. Cycle power on the radio if it has been powered on for more than 5 minutes (RAD-ISM-900-RS-232-BD and RAD-ISM-900-DATA-BD-BUS only) 5. Check that the serial port settings (baud rate, data bits, stop bits, parity and handshaking) on the radio match those on the computer. The factory default values on the radio are 9600, N, 8, 1, no handshaking. You can use the “Auto detect” feature if you are unsure of the radio’s settings. 6. Check that the serial port on the radio is designated as the main serial port
No radio link (radios within 10 feet of each other)	1. Ensure only 1 radio is programmed as the master and all others slaves or repeaters. 2. Check to ensure the Group Parameters are set the same on all radios (Group ID, Security ID, RF Band, Flush Time, Re TX Broadcasts, Repeaters and Blocked MHz) 3. Ensure that no two radios have the same Radio ID 4. On slave radios, if Roaming is not allowed, ensure the Master ID matches the Radio ID of the master radio.
No radio link (field installed)	1. Check to ensure antennas are connected and aimed properly 2. Check that the antenna connections are tight and corrosion free 3. Increase the mounting height of the antenna 4. Increase the gain of the antenna (and/or decrease co-axial cable losses) 5. Check to see if there is another transmitting antenna nearby – re-locate the antenna at least 10 feet horizontally or 6 feet vertically away from all other antennas 6. Check the power supply to ensure sufficient current capacity 7. Check to ensure the center pin of the antenna co-axial cable is not shorted to ground.

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Table 6-4. General Troubleshooting (continued)

Problem	Solution
Able to program radios and establish RF Link but unable to transfer data	1. Two or more radios have the same Radio ID. 2. Check buffer mode 3. Check handshaking 4A. View LED's to find out how far data is going: a. If the TX LED on the master flickers, communications are OK between the master and the PC/PLC – you should then see the RX LED on all slaves flicker b. Check the address of the command to ensure that it matches that of the end device. Check the port settings of the serial devices connected to each slave. c. heck the RS232/485/422 wiring at slave radios d. Check the port settings of the slave serial device 4B If both the TX and RX LED's on both the master and slave radios flash, this means the slave serial device is responding to the commands, but the master device is unable to interpret the response: a. Increase the time-out setting on the master PLC/PC Unable to program radio (using RADLink software)
Able to send data to slave, but with no response from the end serial device (RX LED on slave radio flashes, but TX LED does not flash)	1. Check that the port settings of the slave radio match the port settings of the end serial device (baud rate, parity, data bits and stop bits) 2. Check to ensure Handshaking is either enabled or disabled on both slave radio and end serial device. 3. Double check RS485/422 wiring or swap a null modem for a straight through cable or vice versa. 4. Bypass the radios and connect the master and slave serial devices to ensure they are compatible. 5. Check the buffer mode to ensure compatibility with protocol. 6. Determine what pins on the cable used to program the end serial device are shorted together. On the cable between the slave radio and the end serial device, ensure those same pins are shorted together.

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6.3.1 Performing a Loop Back Test

You can verify that data is making the round trip from a master to slave, and back to the master by doing a loop back test. The test involves shorting pins 2 and 3 on the RS232 port (or shorting the TX+ to RX+ and TX- to RX- of the RS422/485 port) of the slave radio, and sending characters via a terminal program into the master radio. See Figure 6-4. You will then see the characters echoed back onto your terminal program.

To do a loop back test, perform the following procedure:

1. Connect a PC to the master radio and run a terminal program with the com port settings of the PC matching the port settings on the master radio.
2. Connect a Loopback Test Connector to the RS232 port on the slave radio or connect wires to the RS422/485 port on the slave (depending on which is programmed as the primary serial port).
3. Apply power to both radios, and verify the radio link by observing the RF LED.
4. Type characters into the terminal program. If the test is successful, you will see those characters on your terminal program. If not successful, the screen will be blank. Observe the TX and RX LED's on each radio to determine how far the data is going.

Note

For Technical Support, please have the model number of your radio product available and contact:

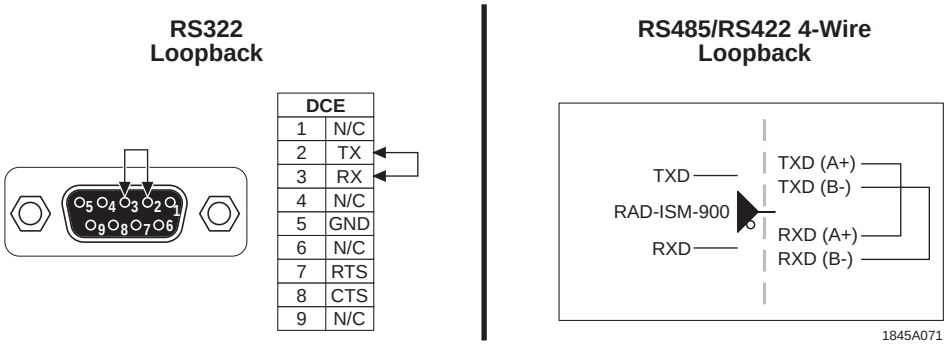

Figure 6-4. RS232 an d RS422.RS485 Loopback Connections

SECTION 7
Transmitting Different Protocols

Section 7 Contents

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7.1 Table of Tested Protocols

The following list of protocols were tested and verified as functional through the radios by an independent third party laboratory:

Function	Protocol
• Flow Automation AutoPilot using	Enron Modbus Protocol
• Bristol Babcock TeleFlow using	BSAP protocol
• Fisher ROC 300 Series using	ROC protocol
• ABB TotalFlow RTU using	PCCU protocol
• OMNI Flow Computer using	OMNI Modbus protocol
• AutoSol RTU 4000 E1 using	AutoSol Modbus protocol
• Basler BE1-851 using	DNP 3.0 Protocol
• SCADAPak LP using	Modbus Gould Modicon RTU protocol
• GE Fanuc using	SNP protocol
• Allen Bradley using	DF1 Half-Duplex

7.2 Considerations for Configuring Various Protocols

Table 7-1 shows how radios should be configured for several different protocols.

Table 7-1. Radio Configuration for Various Protocols

End Device	Native Protocol	Auto-Routing			Port Tested		Port Parameters			RTS/ CTS Rqd?	Notes
		Diasabled	Modbus	DF-1	RS232	RS485	Bit, Parity	Buffer Mode	Baud Rate		
ABB Totalflow	wpp	X			X		8NI	Character	9600	No	
ModiconI	ASCII	X			X		8NI	Character	9600	No	
Daniels	Modbus	X			X		8NI	Character	9600	No	null modem req'd
Daniels	Daniels	X			X		8NI	Character	9600	No	null modem req'd
Barton	Barton	X			X		8NI	Character	9600	No	
Bristol Babcock	BASP	X			X		8NI	Character	9600	No	
GE Fanuc	SNP	X			X		8NI	Packet	9600	No	
Emerson Fisher ROC	ROC	X					8NI	Character	9600	No	
Flow Automation	FA Modbus	X					8NI	Character	9600	No	
Allen Bradley	DFI	X	X	X	X		8NI	Packet	9600	No	null modem req'd
Siemens	Profibus	X			X		8NI	Character	19200	No	
GE Harris	DNP3.0	X			X		8NI	Character	9600	No	
Gauging Systems	Modbus RTU	X	X		X	X	8NI	Packet	19200	No	null modem req'd
Control Micro SCADA PAK	Modbus RTU	X	X		X		8NI	Character	9600	No	null modem req'd
SixNet	Modbus RTU	X	X		X	X	8NI	Packet	9.6, 19.2k	No	null modem req'd
Square-D Power Conditioner	Modbus RTU	X			X	X	8NI	Character	9600	9600	
Campbell Scientific	Modbus	X			X		8NI	Character	9600	9600	
AutoSol RT	asi	X			X		8NI	Packet	9600	9600	null modem req'd

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7.2.1 Allen Bradley Specific Configuration using RS Logix for the SLC Series PLCs

In order to read and write data to/from the I/O modules connected to the RAD-ISM-900-DATA-BD-BUS, you will need to use a Message Instruction. Because the scan time of the PLC program will always be faster than the radios can respond, you must slow the polling down so that the com port server does have to queue messages. If messages are queued up, the response time will slow dramatically.

The following instructions show how to create a short program to poll remote I/O that uses a timer to trigger a poll every second. Alternatively, you could trigger a new message instruction using the done bit (DN) of the previous message instruction.

1. Run the RS Logix software
2. Select **File**, **New**, and enter the processor type.
3. Insert 2 new rungs into the program.
4. Drag and drop a **Timer On-delay** into the right side of the first rung.
5. In the **Timer** parameters box, enter a timer element where data for that timer can be stored (e.g. T4:0)
6. Enter a **time base** of 0.01 seconds
7. Enter a **preset** of 100 to make it a 1 second timer
8. Drag and drop an **Examine if Open** bit to the left side of the first rung.
9. Enter the bit T4:0/DN to have the Done Bit of the 1 second timer trigger the timer. This will create a timer that automatically resets causing it to run continuously.
10. Drag and drop a **Message Block** into the right side of the second rung.

11. Under **Read/Write**, select read if the channel on the I/O module is an input or write if the channel on the I/O module is an output.
12. Under **Target Device**, select 500CPU
13. Under **Local/Remote**, select Local
14. Under **Control Block**, assign an Integer file (N_:_) with 14 elements to store the message instruction – note this is a different location from where the data from the transfer will be stored.
15. Under **Control Block Length**, enter 14. This is the size of the control block.
16. Double Click on the **Setup Screen** for the message block.
17. Under **This Controller**, **Data Table Address**, enter an Integer file location where the data can be stored to or extracted from on your master PLC.
18. Under **Size in Elements**, enter the number of elements (size) of the storage location.
19. Under **Channel**, enter 0 for the RS232 channel (this example assumes you have an RS232 port on the SLC)
20. Under **Target Device**, **Message Timeout**, enter a value of 5. This gives the slave up to 5 seconds to respond – more than enough time.
21. Under **Data Table Address**, enter the register number of the I/O module you wish to read/write from/to. This is determined from the Allen Bradley Memory Map in Section 6.5.1 of this manual, and is influenced by the rotary switch setting on the I/O module.
22. Under **Local Node Addr.**, enter the PLC address that you programmed into the slave radio.

Note

Next you must configure the channel for DF1 communications as described in steps 23 through 37.

23. Double click **Channel Configuration** from the expanded Controller folder.
24. Select the tab **Channel 0 – System**. (this example assumes the RS232 channel is connected to the master radio)
25. Under **Driver** select **Half Duplex DF1 Master**.
26. Under **Baud, Parity** and **Stop Bits**, set them the same as the serial port settings on the master radio.
27. Under **Node Address**, enter a node address for the processor.
28. In the **Process Control Section**, under **Control Line**, select No Handshaking.
29. Under **Error Detection**, select CRC.
30. Under **Polling Mode**, select Msg, Don't allow slaves to initiate.
31. Enable **Duplicate Packet Detect**.
32. Under **Reply Message Timeout**, enter a value of 1 to give 20ms. (Note – in consulting with Rockwell Software, this appears to be a bug in RS Logix. The radios cannot respond within 20ms, however setting this to a higher value causes errors. Different versions of RS Logix software may not have this problem and may require different settings).
33. Under **ACK Timeout**, enter a value of 50 to give a timeout of 1 second.
34. Under **Message Retries**, enter a value of 3.
35. Under **Pre-Transmit Delay**, enter a value of 0.
36. Select **OK** to apply the settings.
37. Download and run the program.

7.2.2 Modbus RTU Specific Configuration using Concept 2.5

Create a new project in Concept. In the Controller Configuration, program the Modbus Port Settings to match the settings of the master radio. Assign the Modbus Port an address of 1.

Note

When configuring any slave RAD-ISM-900-DATA-BD-BUS radios, use caution when choosing a PLC address or it will cause errors (multiple devices with the same address).

1. Create a new FBD section. Open the FFB selection box and place an XXMIT block on the screen. This will control a Modbus command.
2. Double-click the Start pin and assign a bit that will activate the XXMIT block to initiate a Modbus command. This may be a physical switch on the controller or if using multiple XXMIT blocks, the done bit from the previous block. Keep in mind that the START bit must remain on (high) until the XXMIT block has completed its function, or an error will occur.
3. Double-click the Command pin and create a new word that will tell the XXMIT block what type of port function it will perform. For a simple RS-232 Modbus command, enter an initial value of 2#0000000100000000. For an RS-485 command enter an initial value of 2#0010000100000000. See the Detailed Parameter Description of the Command word in the Concept Help file for more information.
4. Double-click the MsgOut pin and create a variable with a WordArr9 for a Data Type. The MsgOut defines what Modbus command will be executed. Set the values in the word array as follows:
   a. Word 1: Enter the Modbus function code. See Table 7-2.

Table 7-2. Function Codes for Modbus

Function Code	Description	I/O Module
1	Read Coil Status	RAD-OUT-8D-REL
2	Read Input Status	RAD-IN-8D
3	Read Holding Registers	RAD-OUT-4A-I & RAD-IN+OUT-2D-1A-I
4	Read Input Registers	RAD-IN-4A-I
5	Force Single Coil	RAD-OUT-8D-REL
6	Force Single Registers	RAD-OUT-4A-I & RAD-IN+OUT-2D-1A-I
15	Force Multiple Coil	RAD-OUT-8D-REL
16	Force Multiple Registers	RAD-OUT-4A-I & RAD-IN+OUT-2D-1A-I

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   b. Word 2: Enter the quantity of registers that will be read or written to. Enter 1 to read or write a single point. Enter 4 to read or write 4 registers (they must be in numerical order, e.g. registers 40001, 40002, 40003)
   c. Word 3: Enter the target slave PLC or RAD-ISM-900-DATA-BD-BUS PLC address.
   d. Word 4: Enter the slave register that will be read or written. If reading/writing multiple registers, enter the first register here. To read 40001, simply type a 1, to write 00050, input 50. The register prefix is not needed.
   e. Word 5: Enter the Master PLC register. This is where data read from the slave is stored, or where data to be sent to a slave is stored.

If you need to send multiple Modbus commands, either transfer multiple MsgOut word arrays into the XXMIT block, or program multiple XXMIT blocks and activate them one at a time with ladder logic.

5. For **MsgLen**, enter a literal value of 5.
6. For **Port**, enter a literal value that corresponds to the PLC port that the master radio is connected to.
7. For **Baudrate**, **Databits**, **Stopbits**, and **Parity**, enter literal values that match the PLC port settings. For no parity, enter 0.
8. Enter a literal value of 1000 (ms) for **RespTout**. This is the port time out settings, and can be optimized after the system is commissioned.
9. Choose a value for the retry limit (**RetryLmt**) and enter a literal value.
10. Enter a start and end delay (**StartDly, EndDly**) of 100 (ms).
11. For **Active**, **Done**, **Error**, **Status**, and **Retry**, variables need to be named, but no register has to be reserved. The **Error** integer can provide some assistance with troubleshooting; see the Concept help file for error codes.
12. Once the XXMIT block is configured, connect to the controller and load the program.

7.3 Cabling/Wiring Considerations for Various Protocols and Hardware

7.3.1 RS-232

The first consideration for ensuring the correct pin to pin wiring between the radio and the end serial device is to determine if the end device functions as DTE (data terminal equipment) or DCE (data communications equipment). This is discussed in section 4.2.1

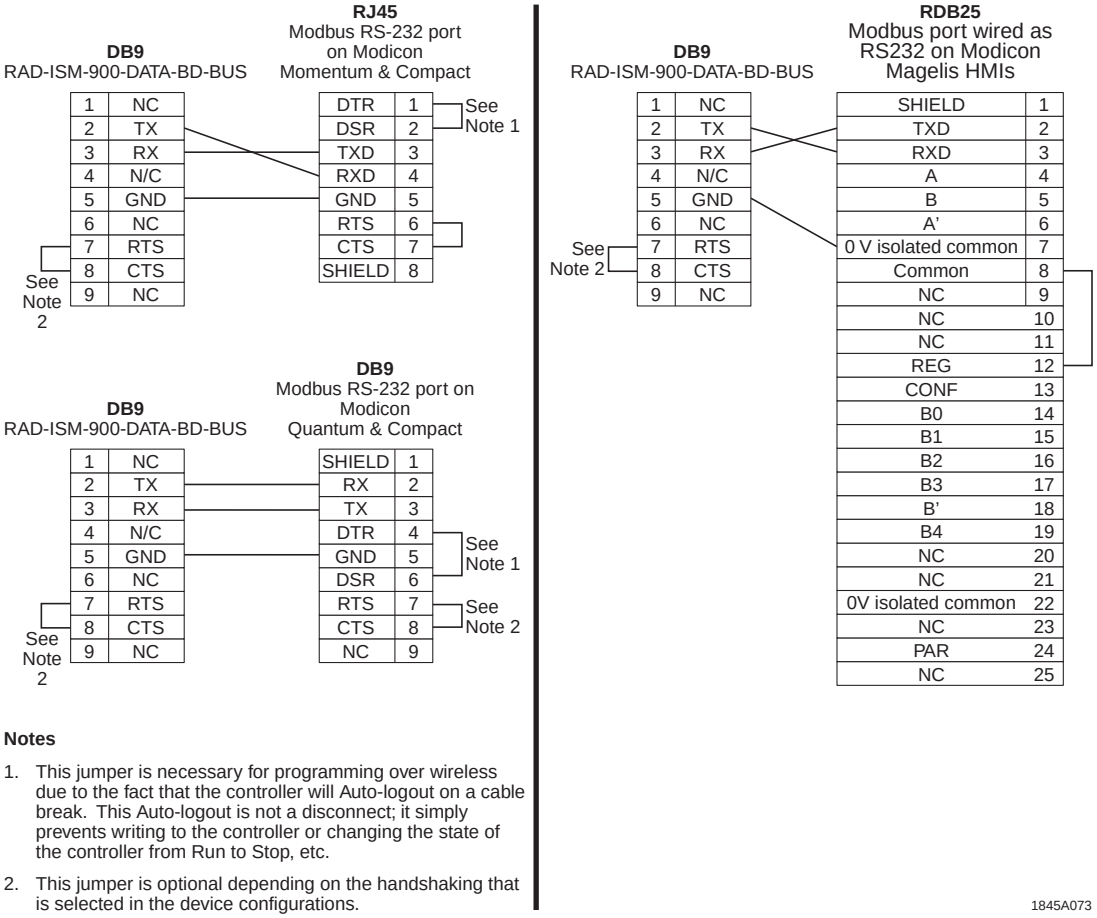
The second consideration is to determine what pins are shorted to other pins on the cable that is used to program the end serial device. For example, if pins 1, 4 and 6 are shorted to each other on the end serial device end of the programming cable, then those same pins must be shorted on the cable connecting the radio to the end serial device. Use a multimeter to measure the cable and determine which pins are connected to which other pins.

Some examples are shown in Figure 7-1.

7.3.2 RS-485/422

The most common problem found in this type of wiring system is reversed TX and RX wires and “Tee’ing” or “Star’ing” of the wiring. Also common is having data reflected back. This is caused by the radio being wired for 4-wire operation but the radio configured for 2-wire operation.

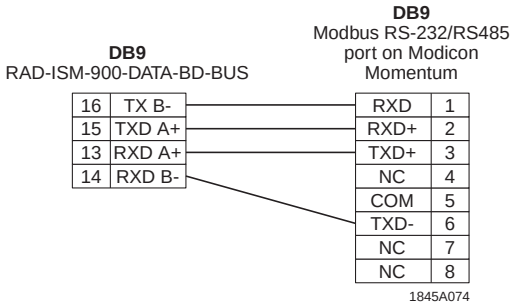
An example is shown in Figure 7-2.



Notes

1. This jumper is necessary for programming over wireless due to the fact that the controller will Auto-logout on a cable break. This Auto-logout is not a disconnect; it simply prevents writing to the controller or changing the state of the controller from Run to Stop, etc.
2. This jumper is optional depending on the handshaking that is selected in the device configurations.

Figure 7-1. Wiring Diagrams for RS232 Radio to PLC Connections



Notes

1. Placing a 120-ohm resistor between 1 & 2 on the Momentum side and 13 & 14 on the RAD-ISM-900 side is required to truly meet the RS422/485 standard. This is a 4-wire full duplex connection.
2. The Modicon Momentum does not support Auto-logout on ports using RS485 protocol; therefore. if programming using this link, the user must be sure to log off the PLC connection. If this is not done, the PLC may lockout future attempts to program it until power has been cycled to the Momentum.

⚠ WARNING

If used in a Class 1, Div. 2 area, do not disconnect equipment unless power has been switched OFF or the area is known to be non-hazardous.

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Figure 7-2. Wiring Diagrams for RS232/RS485 Radio to PLC Connections

SECTION 8

System Architecture

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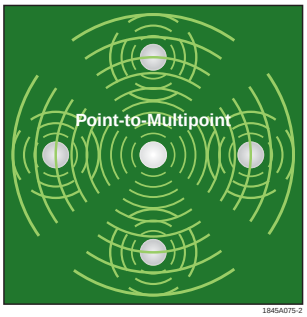
8.1 Point-to-Point 8-1

8.2 Point to Multi-Point or Multi-Point to Point 8-1

8.3 Adding Repeaters (Store and Forward) 8-1

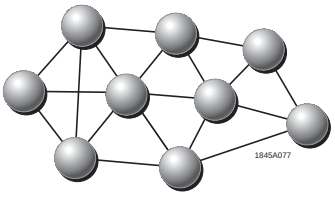
8.1 Point-to-Point

A basic network that involves only two radios is called point-to-point. When data is applied to the serial port of one radio, it automatically appears on the serial port of the opposite radio. No addressing of the end serial devices is required. Note that the system must still operate as master/slave polling to prevent both ends from attempting to transmit data at the same time.



8.2 Point to Multi-Point or Multi-Point to Point

In a Point-to-Multi-Point or Multi-Point-to-Point network, all communications are controlled by the master PLC. Each slave end serial device must have an address programmed into it. Each command from the master contains an address and all slaves hear each command. Only the slave with the matching address will respond. Typically slaves are polled in a sequential fashion. Note that the response time will increase as the number of slaves increases. This type of network can be optimized by polling slaves that require a faster response time more frequently than other slaves.



8.3 Adding Repeaters (Store and Forward)

When a radio is configured as a repeater, it utilizes Store and Forward to transmit the data beyond the range of a single radio. An important note is that all radios in the network must know that there are repeaters, so that if they hear a weak signal direct from the master radio, repeated by the repeater, they do not respond twice. This is a Group setting, see Section 4 for more information.

A repeater will slow the response time. There is no limit of the number of repeaters that can be used in a system. However more repeaters will further slow the response time. With one repeater in a network, slaves that pass data through that repeater will have double the response time. If a slave is connected through 2 repeaters, the response time goes up 5 fold compared to if there were no repeaters. Three repeaters increase the delay 6 fold.

If there are multiple paths that a slave radio can take to get its data to a master, by allowing Roaming (see section 5.5), the slave can take an alternate path if its primary path is blocked. It is important to note that antenna selection must be reviewed to ensure that all possible paths are within the beam width of the antennas.

SECTION 9
System Planning

Section 9 Contents

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9.1 Accessing the Site

To achieve the best radio performance possible, the installation sites for remote/repeater and master stations have to be given careful consideration. The primary requirements for a reliable installation include:

- Antenna placement that allows for line-of-sight or adequate signal strength
- Primary power source that provides required current
- Protection of radio equipment from exposure to weather or environmental extremes
- Suitable entrances for antenna, lightning arrestor, interface or other required cables

These requirements can be quickly assessed in most applications. A possible exception is the first item, verifying that a clear line-of-sight exists. A non-obstructed path is ideal, however, minor obstructions in the signal path will not always block communication. In general, the need for a clear path becomes greater as the transmission distance increases.

9.2 Path Quality Analysis

With the exception of short range applications, a path loss study is generally recommended for new installations. The exceptions include distances of less than 1000 feet where no test is required in 90% of applications, and where a test is done with a functional 900MHz 1 watt Phoenix Contact radio. However, where towers would need to be built just to do the test, a path loss study is more practical. A path loss study predicts the signal strength reliability and estimates the fade margin of a proposed radio link. While terrain, elevation and distance are the major factors in this process, a path loss study also considers antenna gain, coaxial cable loss, transmitter power, and receiver sensitivity to arrive at a final prediction.

Path loss studies are normally performed by a communications consultant, wireless hardware vendor, or a system integrator who uses topographic maps or a software path analysis to evaluate a proposed path.

Although path studies provide valuable assistance in system planning, they are not perfect in their predictions. It is difficult, for example, to consider the effects of man made obstructions or foliage growth without performing an actual on-air-test. Such tests can be done using temporarily installed equipment.

9.3 Signal Strength

When is 'enough' really enough? The strength of radio signals in a well designed SCADA system must exceed the minimum level needed to establish basic communication. The excess signal is known as the fade margin, and it compensates for variations in signal level which may occur from time to time due to foliage growth, minor antenna misalignment, or changing atmospheric losses.

While the required amount of fade margin differs from one system to another, experience has shown that a level of 20 to 30 dB above the receiver sensitivity threshold is sufficient in most SCADA systems. The DATA Series provide a means for direct measurement of received signal strength using a DC voltmeter, terminal program, or diagnostic software. Consult section 7.2 for more information.

9.4 Antennas and Cabling

The single most important item affecting radio performance is the antenna system. Careful attention must be given to this part of an installation, or the performance of the entire system will be compromised. High quality, gain antennas should be used at all master and remote stations. The antennas should be specifically designed for use at the intended frequency of operation (902 to 928MHz) and with matching impedance (50 ohms).

SCADA communication antennas are made by several manufacturers and fall into two categories—omnidirectional, and yagi-directional. See Figure 9-1. An omnidirectional antenna provides equal radiation and response in all directions and is therefore appropriate for use at master stations which must communicate with and array of remote stations scattered in various directions.

At remote stations, a directional antenna, such as a yagi is typically used. Directional antennas confine the transmission and reception of signals to a relatively narrow beam width, allowing greater communication range, and reducing the chances of interference from other users outside the pattern. It is necessary to aim these antennas in the desired direction of communication (i.e., at the master station).

The end of the antenna (furthest from support mast) should face the associated station. Final alignment of the antenna heading can be accomplished by orienting it for maximum received signal strength. Do this while monitoring the RSSI with a DC voltmeter.

9.4.1 Coaxial Cable Considerations

The importance of using a low-loss antenna coaxial cable is often neglected during radio installation. Using the wrong cable can cause huge reductions in efficiency and these losses cannot be recovered with any amount of antenna gain or transmitter power.

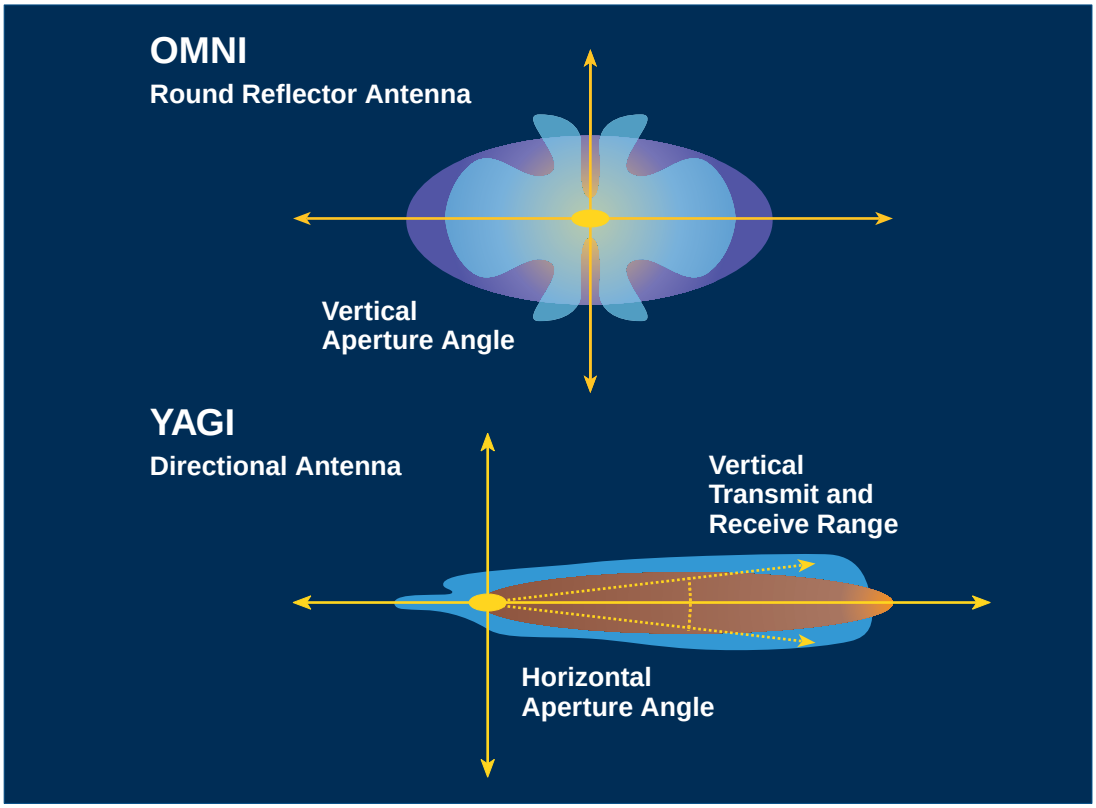

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Figure 9-1. OMNI-directional and YAGI-directional Antenna Radiation

For every 3dB of coaxial cable loss, half the transmitter power will be lost before reaching the antenna. The choice of coaxial cable to use depends on: 1) the length of cable required to reach the antenna, 2) the amount of signal loss that can be tolerated, and 3) cost considerations. For long range transmission paths, where signal is likely to be weaker, a low-loss cable type is recommended, especially if the length of the cable must exceed 50 feet.

For a short range system, or one that requires only a short antenna coaxial cable, a less efficient cable may be acceptable, and will cost far less than large diameter cable. To judge the effectiveness of various cables at 916 MHz, refer to Table 9-1.

Table 9-1. Cable Types and Single Loss (db) at 916 MHz

Cable Type	Loss (db/100 ft)
RG-58	16.5 db
RG-213	7.6 db
LMR 400	3.9 db
LMR 600	2.5 db

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9.5 Antenna Mounting Considerations

The antenna manufacturer's installation instructions must be strictly followed for proper operation of a directional or omnidirectional antenna. Using proper mounting hardware and bracket ensures a secure mounting arrangement with no pattern distortion or de-tuning of the antenna. The following recommendations apply to all antenna installations:

A. Mount the antenna in the clear, as far away as possible from obstructions such as buildings, metal objects, dense foliage, etc. Choose a location that provides a clear path in the direction of the opposite antenna. If antenna is co-located with another antenna, try to get at least six (6) feet vertical or ten (10) feet horizontal separation between the two.

B. Polarization of the antenna is important. Most systems use a vertically polarized omnidirectional antenna at the master station. Therefore, the remote antennas must also be vertically polarized (elements perpendicular to the horizon). Cross-polarization between stations can cause a signal loss of 20 decibels (dB) or more.

9.6 Maintaining System Performance

Over time, any communications system requires a degree of preventative maintenance to ensure peak operating efficiency. Periodic checks of master and remote sites should be made to identify and correct problems before they become threats to system operation. The following areas should be given special attention:

9.6.1 Antennas and Coaxial cable

Visually inspect the antenna and coaxial cable for physical damage, and make sure that the coaxial connections are tight and properly sealed against the weather. For directional antennas, ensure that the antenna heading has not shifted since installation.

The SWR (Standing Wave Ratio) of the antenna system should be checked from time to time using a through-line wattmeter. Defects in the antenna system will frequently show up as reflected power on the meter. It is good practice to accept only a maximum reflected power of about 5%; this corresponds to an SWR of approximately 1.5:1. For any condition exceeding this value, search for and correct the cause—damaged antenna, defective or improperly installed connectors, water in the coaxial feedline, etc.

9.6.2 Cable Connections

All power, data, and ground connections should be secure and free of corrosion.

9.6.3 Power Supply

The voltage of the station power supply should be measured to verify that it is within the operating specifications for the radio. If possible, the radio should be keyed during this test, to ensure maximum current draw from the supply. Batteries, if used, should be checked for charge level and signs of leakage or corrosion.

SECTION **10**

Using AT Commands and Remote Diagnostics

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10.1 General

The DATA series of radios can be programmed using a specialized subset of the industry standard AT commands through a terminal program. This is an alternate to programming using the RadLink software (or the internal DIP switches on the RAD-ISM-900-DATA-BD-BUS only). Programming using AT commands is slightly more complex and therefore recommended only for advanced users.

10.2 Terminal Programs and Getting Connected

Use of the AT commands requires a Terminal program on your PC.

10.2.1 Using RadLink's Terminal Program

There is a Terminal Program supplied with the RadLink software. It can be accessed from the "Help" pull down menu. Set the Com Port settings on the PC to match the port settings on the radio. The Com Port settings on the PC can be adjusted in the RadLink software from the "Project" pull down menu. For more information on configuring Com Ports, refer to Section 4, Paragraph 4.3.

If using the remote diagnostics port (or the secondary port), the port settings are fixed at 19,200 baud, no parity, 8 data bits, one stop bit and no handshaking.

10.2.2 Using HyperTerminal Program in Windows

Run the HyperTerminal program supplied with Windows and make the following settings:

1. Select “File”, “New Connection” from the pull down menu.
2. Enter a name and select a symbol.
3. Select the com port the radio is connected to under “Connect Using…”
4. Under “Port Settings”, enter the baud rate, data bits, stop bits, parity and handshaking. These settings must match the radios port settings. If using the radio’s primary port, they can be adjusted by the user, with the factory default values being 9600 baud, 8 data bits, 1 stop bit, no parity and flow control (handshaking) set to none. If using the secondary (or remote diagnostics port), the port settings are fixed at 19,200 baud, 8 data bits, no parity, 1 stop bit and no flow control.

10.3 Programming a Local Radio

Note

If your RAD-ISM-900-RS-232-BD or RAD-ISM-900-DATA-BD has been powered on for more than 5 minutes, it can only be programmed through the remote diagnostics port. Cycle power on the radio to reset the timer. This feature was implemented to allow the radios to be compatible with telephone modems for hybrid networks which have both telephone and radio modems.

10.3.1 Data Transfer and Configuration Modes

There are two modes of operation for the radio, Data Transfer and Configuration. When in Data Transfer Mode, the content of the information sent to and from the radio is ignored, and simply passed on through the RF port or serial port. When in Configuration Mode the radio assumes a device is programming it and it analyzes the content of the message to see what parameter to adjust. When a radio is first powered up, it defaults to Data Transfer Mode.

The exception to the above is if you are configuring through the remote diagnostics port (or secondary port) while data is being passed through the primary port. In this situation the radio multi-tasks to handle the requests from both ports. See section 11.4 for more information on remote diagnostics.

a. Local Programming Commands

Programming Commands shown in Table 10-1 can be used when programming a radio locally.

Table 10-1. Local Rrograming Commands

Command	Description
+++	Radio enters Configuration Mode.
AT	Attention. Returns 'OK' when the radio is in configuration mode.
ATE0	Disable echoing of characters when in configuration mode. Default.
ATE1*	Enable echoing of characters when in configuration mode.
ATI or ATI0	Display software revision information.
ATI1	Display radio configuration S-registers only. (S0…S49)
ATI2	Display diagnostic S-registers only. (S50…S99)
ATI3	Display radio manufacture information.
ATI4	Display radio to PLC mapping information.
ATI5	Display a list of error codes.
ATSn=V	Sregister n is changed to value V. (n is a decimal number)
ATSn?	The value is S register n is output.
ATH	Data mode. Used to exit configuration mode and enter data transfer mode.
ATZ	The configuration is loaded from EEPROM.
AT&Z	The configuration is reset to factory defaults.
AT&W	The configuration is written to EEPROM.
AT&R	Reset the radio's microcontroller unit.

***** This command is automatically enabled when using the RadLink Terminal program

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NOTE

A carriage return <CR> (or enter key) must follow each command entered.

b. Additional Command Notes

1. Multiple commands are allowed on a single command line with the exception of ATD, ATE and ATH.
2. Up to 40 characters are allowed on a single command line.
3. All command lines must be followed with a carriage return <CR>.
4. All white space characters within commands will be ignored.
5. All commands will return an "OK" upon completion with the exception of ATH and AT&R.

c. Programming Example

An example of a typical sequence for programming a local radio would be as follows:

1. +++ <CR> Sets the radio to configuration mode.
2. AT <CR> Confirms the radio is in configuration mode. Radio should return an "OK".
3. ATE1 Enables echoing of characters so that you can see on the screen what characters are being typed. (not necessary with RadLink terminal program).
4. ATS0=x Sets S register "0" to value "x". S register 0 is the Group ID and therefore "x" can be a value ranging from 1 to 63 decimal.
5. Repeat Step 3 with all other registers.
6. AT&W The configuration is written to the radios EEPROM.
7. ATH The radio is returned to data transfer mode.
8. Cycle power to the radio for the new settings to take effect.

10.3.2 S-Register Description

Table 10-2 describes each of the S-Register commands

Table 10-2. Radio Parameter Reference Chart

RX LED	Description	S-Register
Group ID	Each Group of radios that are to communicate with each other must have the same Group ID Number. Also changes hopping sequence.	S0
Radio ID	Each radio within a Group must have a unique Radio ID to identify it from the other radio's within the Group.	S1
Security ID	Each Group of radios must also share the same Security ID in order to communicate with each other.	S2
Radio Mode	This register defines the function of the radio, as Master, Slave or Repeater/Slave	S3
Repeater in Group	This parameter is selected on all radios whenever a Repeater/Slave radio mode is present in the Group.	S4
Retransmit Broadcast	This parameter causes master radio and repeaters to send duplicate packets from master (and repeaters) radio.	S5
RF Band	Selects the unique Frequency Band that the radio utilizes while in hopping sequence.	S6
Roaming	Allows slave radio to roam to acquire any Master ID or Repeater within its' own Group.	S7
Fixed Master ID	This parameter can be set to specify a particular Master ID to use when Roaming is disabled.	S8
Retries	This parameter sets the number of communication retries of a data packet before being discarded.	S13
Wait Time	This parameter sets the maximum period of time that packetized data may be buffered prior to TX by radio.	S14
Flush Timeout	This parameter sets the max. time that the auto-routing tables are kept before being automatically rebuilt.	S15
Compatibility	This parameter can be set only on RS232-BD radios to work with previous firmware releases V1.xx.	S19
Baud Rate	This critical parameter sets radio port baud rate and MUST match baud rate of attached PC, controller, etc.	S20
Data Bits	Sets the radio data port for specific data bits per character of attached serial device.	S21
Stop Bits	Sets the radio data port for specific stop bits per character of attached serial device.	S22
Parity	This parameter is set to match serial port parity of attached serial device.	S23
Handshaking	This parameter allows radio to use hardware handshaking to attached serial device if required by application.	S24
Auto-Routing	A feature that increases reliability when using Modbus RTU or DF1 protocol by retransmitting errored packets.	S25
Buffer Mode	Determines if the receiving radio buffers the message or if it sends each byte out as they arrive.	S26
Blocked Frequencies	This parameter allows user to 'block' or avoid up to 12 specific frequencies used in radio hop pattern.	S30 thru S41
Emulation Mode	Allows user to configure the DATA-BD-BUS radio for point to point I/O, radio modem or PLC Emulation mode.	S100*
PLC Address	Once PLC emulation mode has been selected this parameter must be assigned to give I/O its polling address.	S101*
Main Serial Port	This parameter allows user to designate primary port for transporting user data, select RS232, 485 or RS422.	S102*
Sleep Mode	This parameter allows user to choose a power saving strategy for DATA-BD-BUS.	S103*
Current Time	Current Time parameter is selectable in the configuration program when using PLC emulation mode.	S110*
Start Time	Related to sleep mode, tells the DATA-BD-BUS radio what time to wake up for its polling of internal I/O registers.	S111*
On Timer	'Interval' which keeps radio power on for a specified length of time, 0-255 minutes, after Start Time occurs.	S12*
Off Timer	When radio timer has been turned on (S112) this parameter sets the timer in minutes as to when to turn off.	S113*

* Registers S100 and up are only available on the RAD-ISM-900-DATA-DB-BUS

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10.4 Remote Radio Programming

A slave radio can be programmed through the master radio using AT commands. You can connect to the master radio through either its primary or secondary (remote diagnostics) port. Note that the radios must have RF communications prior to being able to pass the configuration changes to the slave. Therefore brand new radios that are straight out of the box, cannot be programmed remotely since they will not have RF communications.

Warning: Changes to a remote radios configuration can be made while the system is passing data, however caution must be taken to ensure a parameter change does not cause the radio to lose RF communications with the master. For example, if the Group ID was changed on a slave and the change implemented (written to the slave's EEPROM and the microcontroller reset), that slave would lose RF communications with the master until the master's Group ID was changed to match the slave.

Similarly, if a port setting such as baud rate were to be changed on a slave, it might lose the ability to communicate with the end serial device connected to it. Therefore caution must be exercised when remotely programming a radio.

a. Remote Programming Commands

The commands shown in Table 10-3 can be used when programming a radio remotely.

Table 10-3. Remote Rrograming Commands

Command	Description
+++	Radio enters Configuration Mode.
AT	Attention. Returns 'OK' when the radio is in configuration mode.
ATE0	Disable echoing of characters when in configuration mode. Default.
ATE1*	Enable echoing of characters when in configuration mode.
ATI or ATI0	Display software revision information.
ATSn=V	Sregister n is changed to value V. (n is a decimal number)
ATSn?	The value is S register n is output.
ATDn	Specifies address of radio for remote diagnostics (Command can be sent into a master radio only). "n" is the Radio ID of the slave. If no "n" value is specified, the address of the master radio is assumed.
ATH	Data mode. Used to exit configuration mode and enter data transfer mode.
ATZ	The configuration is loaded from EEPROM.
AT&Z	The configuration is reset to factory defaults.
AT&W	The configuration is written to EEPROM.
AT&R	Reset the radio's microcontroller unit.

***** This command is automatically enabled when using the RadLink Terminal program

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NOTE

A carriage return <CR> (or enter key) must follow each command entered.

b. Additional Command Notes:

1. Multiple commands are allowed on a single command line with the exception of ATD, ATE and ATH.
2. Up to 40 characters are allowed on a single command line.
3. All command lines must be followed with a carriage return <CR>.
4. All white space characters within commands will be ignored.
5. All commands will return an "OK" upon completion with the exception of ATH and AT&R.

A typical sequence for programming a remote radio would go as follows:

1. +++ <CR> Sets the radio to configuration mode.
2. AT <CR> Confirms the radio is in configuration mode. Radio should return an “OK”.
3. ATE1 Enables echoing of characters so that you can see on the screen what characters are being typed. (not necessary with RadLink terminal program).
4. ATDn Gets the attention of the remote radio where “n” is the Radio ID
5. ATS13=x Sets S register “13” to value “x”. S register 13 is the Retries and there fore “x” can be a value ranging from 0 to 255 decimal.
6. Repeat Step 3 with all other registers.
7. AT&W The configuration is written to the radios EEPROM.
8. AT&R The radio’s microcontroller is reset, causing it to read the configuration data from EEPROM. Your new settings will now take effect and the radio will automatically start up in data transfer mode (Therefore the ATH command is not necessary).

10.5 Remote Diagnostics

There are two methods of performing remote diagnostics; basic diagnostics through the RadLink software or more comprehensive diagnostics using AT commands in a Terminal program reading S registers. The RadLink software, through the master radio, allows a user to view and change all configuration data on a slave or repeater and in addition, shows the RSSI, power supply voltage and internal temperature.

By using the AT commands in a Terminal program, a user can view all of the above information, and in addition access the following diagnostic information:

- Number of valid packets received
- Number of corrupt packets received
- Maximum number of retries data is transmitted
- Turn on/off a fixed frequency carrier for VSWR and power output tests

10.5.1 Remote Diagnostics using AT Commands

Using a subset of the industry standard AT commands, diagnostic information can be obtained through the master radios secondary (remote diagnostics) port while data is passing through the primary port. The network must have RF communications with all slaves.

10.5.2 The Remote Diagnostics Port

a. On the RAD-ISM-900-RS232-BD

The mini DIN connector on the side.

b. On the RAD-ISM-900-DATA-BD

If you selected RS-232 as the primary port, it will can be either RS422 (4-wire) or RS485 (2-wire) depending upon the position of internal DIP switch #2. Or, if the RS485/422 port is the primary, then the RS232 port is the remote diagnostics port.

c. On the RAD-ISM-900-DATA-BD-BUS

This product cannot act as a master and provide remote diagnostics. It can function as a slave and have remote diagnostics performed on it with either of the above two radios as its master. Or you can disconnect the master PLC/PC from the radios primary port and obtain remote diagnostics through this port.

We recommend that you familiarize yourself with the AT commands and S-Registers in this section . In addition, we recommend that you familiarize yourself with the diagnostic registers in Table 10-4.

Table 10-4. Diagnostic Registers

Register	Name (Attributes)	Description
S10	RSSI (read only)	This register contains the average signal strength (dBm) of all packets received by the radio. The value in this register will be a positive number. Add the (-) negative sign and dBm to express in decibels. Note: A value of –151dBm indicates that there is no RF link.
S16	Power Supply Voltage (read only)	This register contains the power supply voltage +/1V.
S17	Internal Temperature (read only)	This register contains the internal temperature in degrees Celsius. Valid range is –40 to 70C. **Note:** A value of –69C indicates there is no temperature sensor installed.
S51	Number of valid packets received (read only)	This register contains the total number of packets that were received by the radio with no errors since the radio was powered on. Range is 0 to 65535. The register will eventually overflow and reset to 0 once the maximum count has been achieved. Slave radios receive transmission packets from the master regardless if data is being sent through the radio. The master radio will not receive anything from its slaves unless data is put on the slave radios serial port. A slave can expect to receive approximately 13 packets per second.
S52	Number of invalid packets received (read only)	This register contains the total number of packets that had a CRC error since the radio was powered on. Range is 0 to 65535. By comparing registers S51 and S52, one can get a measure of the percent of packets that arrive error free. This aids in determining the response time, how much interference/multi-pathing is occurring and what impact features such as Re Tx Broadcasts, Auto-routing or Retries might have or should be set to.
S73 & S79	Maximum Transmit Retries (read only)	This register contains the maximum number of times a radio had to retransmit a packet before it got through or gave up, since the radio was powered on. This functions as a “high water” marker by incrementing the value whenever a larger number of retries has been attempted. This lets a user know the worst case scenario of actual retries. Valid range 0 to 49. S73 contains the downstream count (master to repeater or slave) and S93 contains the upstream count (slave to repeater or master)
S99	Continuous Carrier Transmit Test (read only)	Writing a 1 to this register causes the radio to transmit on a single frequency and not to hop. This is useful for performing VSWR (voltage standing wave ratio) tests and power output tests. Writing a 0 or cycling power to the radio resets the register. **WARNING** **This puts the radio into an illegal mode of operation. This should only be done to quickly test the radio and for a maximum of 15 minutes to minimize interference to other ISM band users. Data cannot be received by a remote radio in this test mode.**

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To perform remote diagnostics, do the following:

1. Connect to the master radio's remote diagnostics port and run a terminal program.
2. Set the serial port settings on the terminal program to 19,200 baud, N, 8, 1 with no handshaking.
3. AT <CR> Checks for master radio acknowledgment. Radio should return an "OK".
4. ATE1 Enables echoing of characters so that you can see on the screen what characters are being typed. (not necessary with RadLink terminal program).
5. ATDn Checks for acknowledgment of the remote radio where "n" is the remote Radio ID

1. ATS51? <CR> Queries register S51.
2. ATS52? <CR> Queries register S52.
3. ATS99=1 <CR> Turns on the continuous carrier test mode.***
4. ATS99=0 <CR> Turns off the continuous carrier test mode.

WARNING

This puts the radio into an illegal mode of operation. This should only be done to quickly test the radio and for a maximum of 15 minutes to minimize interference to other ISM band users. Data cannot be received by a remote radio in this test mode.

10.5.3 Remote Diagnostics using RadLink Software

The RadLink software allows a user, through the master radio, to view all configuration parameters of a slave or repeater. The network must have RF communications; therefore the Group Parameters must already be set. Perform remote diagnostic using the following procedure:

1. Connect your PC to the master radio's remote diagnostics port and run the RadLink software*
2. Set the Com port settings to 19,200 baud, 8 data bits, 1 stop bit and no parity. The remote diagnostics port settings are fixed at these values.
3. Select "Project", "Create New Project…" from the pull down menus.
4. Enter a file name for your project.
5. Enter the Group Parameters that your network uses.
6. Enter the Radio ID for each radio and a Radio Name. "Save" each radio, then select "New Radio" to get a new screen for each radio.

Note

The "Save Radio" and "New Radio" functions use the same button. The function (and description) of the button toggles when selected.

10.5.4 The Remote Diagnostics Port

a. On the RAD-ISM-900-RS232-BD

The mini DIN connector on the side

b. On the RAD-ISM-900-DATA-BD

if you selected RS-232 as the primary port, it will can be either RS422 (4-wire) or RS485 (2-wire) depending upon the position of internal DIP switch #2.

c. On the RAD-ISM-900-DATA-BD-BUS

This product cannot act as a master *and* provide remote diagnostics. It can function as a slave and have remote diagnostics performed on it with either of the 2 above radios as its master. Or you can disconnect the master PLC/PC from the primary port and use this port to use remote diagnostics.

Refer to Figure 10-1. On the right-hand side of the RadLink software, the radios that are part of this project will appear. An “M” in a circle means the radio is a master, an “S” means it is a slave and an “R” means it is a Repeater. A green colored icon of the radio means that radio has successful communications with the RadLink program, whereas a red colored radio icon means that radio cannot be communicated with. When successfully viewing remote radios, the screen will appear as follows:

- The RSSI is presented in –dB. The value for the master radio is the average of all the slaves.
- The Voltage is the power supply voltage in volts, +/-1V.
- The internal temperature is expressed in degrees Celsius. It is normal for the master radio to have a much higher internal temperature, due to the higher duty cycle of its power amplifier than the slave radios.

Note

Remote diagnostics communications functions are a lower priority to data communications occurring through the primary port. Therefore updates will occur more slowly if traffic on the primary port is heavy. In some cases diagnostics may not be possible under extremely high duty cycles.

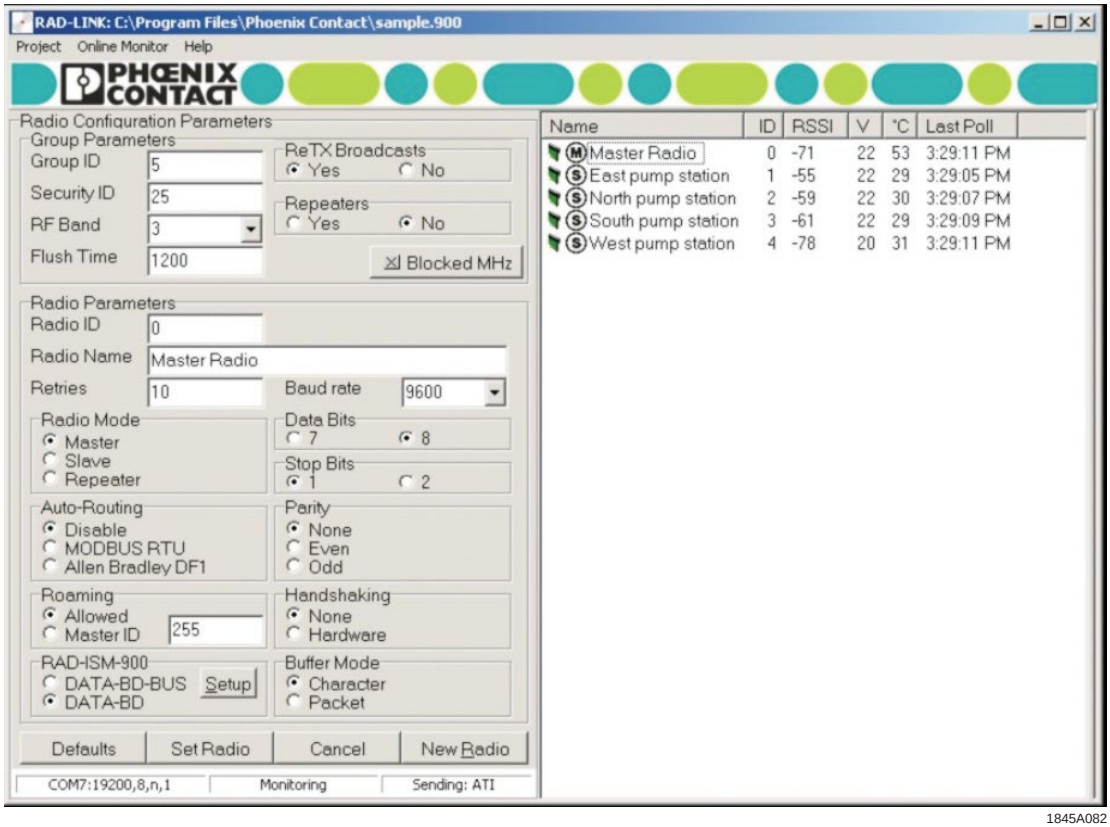

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Figure 10-1. Screen Showing Parameters for Various Radios

The Group Parameters are grayed out because if you change any of them, you will lose communications with that radio.

To begin remotely analyzing the radios, select “Online Monitor” from the pull down menus and click on “Monitor” so that a check mark appears next to it. To turn off remote monitoring, uncheck “Monitor”.

To view individual parameters of a radio, highlight that radio. To change a radio’s parameters, refer to Figure 10-2 and follow the below procedure.

1. Highlight the radio.
2. Make the parameter changes.
3. Select “Save Radio” to save those changes to the PC.
4. Select “Set Radio” to download those changes to the remote radio.

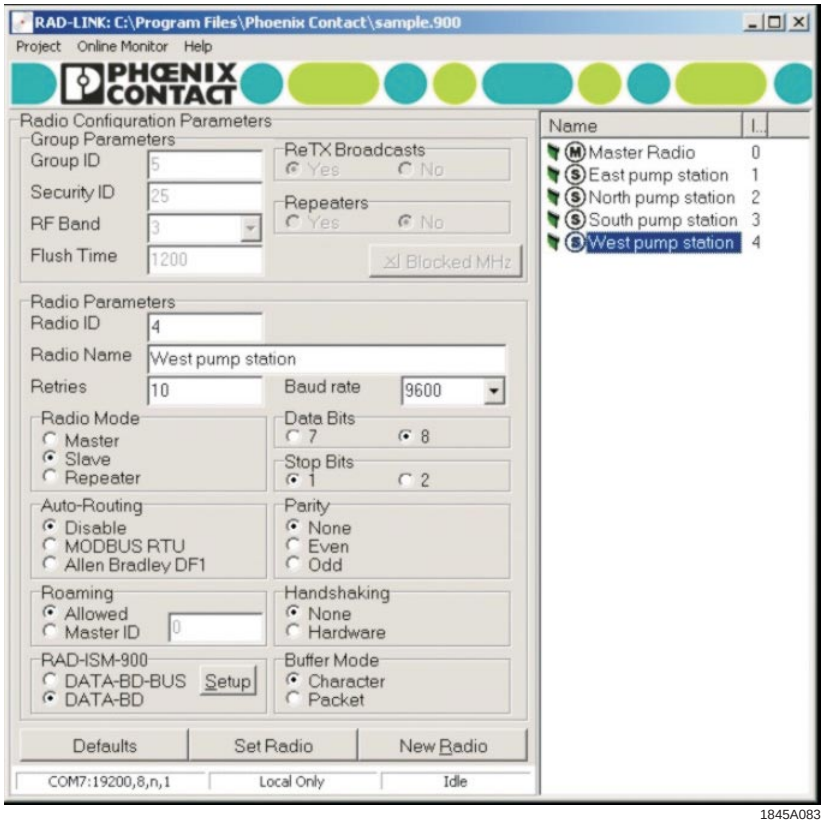

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Figure 10-2. Radio List in RadLink Software

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